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Astronomy of Position*

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Introduction. In coöperating with the Editors of POPULAR ASTRONOMY in a review of positional astronomy I find that although many important developments have occurred in the last fifty years, yet, as the stars move so slowly, it seems that a better picture may be presented by allowing the semi-centennial of POPULAR ASTRONOMY to serve also as a bi-centennial of positional astronomy. The review will be imperfect and quite statistical, but our work is always that way. The effort is to present something of interest to the student.

It was 200 years ago that Bradley at the Greenwich Observatory commenced observations of the sun, moon, planets, and the brighter stars, with an accuracy such that his positions have been valuable for determining planetary motions and motions of the stars ever since, and it seems worth while to review briefly some of the things observers have been doing as to positions of the stars in the two centuries since Bradley's time, and to indicate what they hope to do as the remaining years of the present century pass.

We shall deal here mostly with observational results as tabulated in catalogs of positions and motions of the stars. The right ascension of the Pole Star as Bradley observed it was $0^h\,45^m$; today it is $1^h\,45^m$, although the star moved across the sky but nine seconds of arc. This change of one hour in its coördinate is due to the motions in the coördinate planes of reference which have to do also with problems in the solar system. These may be considered in a separate review.

Instruments. The instruments used in 1750 were a small transit and a mural quadrant. The mural circle replaced the quadrant in 1810. The transit and circle were also combined into a transit circle, the most famous of which was that by Airy in 1850. The vertical circle was introduced by Struve in 1835. The transit circle, the transit instrument, and the vertical circle have been the standard instruments for position work. They are subjected to rigorous examination for division errors of the circles; irregularities of the pivots; errors in the micrometer screws; flexures; and so on. Photographic telescopes with wide-angle lenses and large plates are now relieving the standard instruments of much differential work on faint stars.

There has been some success in the experiments both with photographic and with photoelectric methods of recording transits of bright

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stars. The errors in both cases, however, are larger than those in visual methods. No practicable way has been found for determining nadir readings, or for observing the sun and stars in the day time by these methods, as must be done in fundamental work.

The early observations were taken "eye and ear"; recording by key and chronograph came into use around 1850. The writing chronographs were supplanted later by printing chronographs, and now electronic photographic chronographs controlled by crystal oscillators are coming into use. The travelling thread and automatic registration were introduced 50 years ago. The micrometer threads were travelled by hand at first, but later by some mechanical device.

The micrometers on the transit circles at the Naval Observatory, as recently developed by C. B. Watts, have built into them small synchronous motors actuated by remote control from vacuum tube oscillators. The observers with a key impose differential frequencies on the oscillators, set approximately for the diurnal motion of a star, causing the motors to move the threads with the star. With these micrometers the absolute personal equations of the observers and the probable errors of transit are both reduced to a few thousandths of a second of time. Timed photographic registration of the readings of the micrometer heads does away with the chronograph and its troublesome relay system.

Clocks. The old clocks exposed to large daily and annual changes in temperature had large daily and annual variations in rate. Some 50 years ago the Riefler clocks with invar pendulums, kept under constant barometric pressure, were installed in clock vaults kept at uniform temperatures. More recently the Shortt clocks, with free pendulums controlling slave clocks, maintain very nearly constant rates over long periods. And finally the oscillating crystal clocks are keeping almost perfect time over shorter periods. These are now in general use for broadcasting standard time. The daily rate of Hornsby's clock, (1777), changed as much as $0^s.30$ in a day, while now the rates of the Shortt clocks stay within $0^s.01$ months at a time. In fact the clocks are now more nearly accurate than the observations. The rates are so nearly constant that accurate time may be determined at any instant, day or night.

Methods of observing. In strictly fundamental observations two fundamental reference points are determined, both for the right ascensions and for the declinations, and an independent spacing of the stars is carried out, in right ascension by using observations of clock stars extending over 6 to 18 hours, and in declination by using the graduated circles. The meridian of the instrument is adjusted to the pole by azimuth determinations from circumpolar stars. From group means of these the positions of meridian marks are determined, and the hourly azimuth of the instrument, day or night, may be read from these marks. The preliminary declinations depend upon nadir readings of the circles, but these are adjusted finally to correspond to the pole point of the

circles determined from circumpolar observations, and an independent determination of the refraction is included in the solution for the pole. Day effects are determined by observing bright stars around the sun in the daytime, and comparing such positions with the night positions of the same stars. The equinox of the clock stars and equator point of the circles are determined from observations of the sun and planets. The instrumental constants are determined every few hours, and the observations extend throughout the day and night. An observer at Pulkowa, for instance, has an 18 hour tour, from early in the morning until after midnight. The methods by which such observations are reduced and formed into catalogs may be found in the Washington Catalog 1920, and elsewhere.

Independent observations are often taken omitting the observations of the sun and planets. The equinox of the clock stars is assumed, and the declinations depend upon the pole point of the circle. Such declinations may have considerable systematic errors at the equator. In general differential work positions of the clock and azimuth stars are assumed as known. And in strictly differential work, or zone work, zero corrections and their variations in both coördinates are determined from known positions of reference stars observed in the zone. Photographic plate reductions are of this character.

Earlier Observations. The fundamental observations of the sun, moon, planets, and the standard stars, begun at Greenwich in 1750, have been continued there ever since except as suspended by war conditions in 1940. The observations at Paris, begun in 1800, stopped with war conditions in 1914. The observations at Pulkowa, begun in 1840, completed a century at the time of the destruction of this great observatory in 1941. Observations at Radcliffe extended from 1777 to 1887. Cape and Washington began observations a hundred years ago, and at these two observatories every effort is being made to keep the fundamental series continuous through the present critical period. And there have been many shorter series of observations of the sun and planets. Standard star work has been carried on also at Madras, Melbourne, Cordoba, and Cape in the southern hemisphere, and at numerous European observatories. The Cordoba General Catalog, 1875, contains 32,000 stars. All together upwards of one hundred series of observations taken on some 25 standard instruments from 1830 to 1930 have been considered of sufficient accuracy to be used in the construction of recent fundamental systems. For individual stars the Albany General Catalog made use of 238 catalogs from 1750 to 1930.

During the first half of last century there was great activity in observing fainter stars starting with Lalande's observations of 47,000 stars; then Bessel with 62,000; Argelander and Lamont, each with 40,000; Gilliss at Santiago and the observers at Washington added 40,000 southern stars; and later Gould at Cordoba increased this with

73,000 stars. And there were many others. About the middle of the century extensive programs for general systematic charting of the stars were started.

Durchmusterungen. About 1850 Argelander at Bonn took up a systematic survey of the sky from the north pole to two degrees south of the equator, recording the magnitudes and approximate positions of all stars to between the 9th and 10th magnitudes, totaling 324,000 stars. The survey was continued from —2° to —23° declination by Schönfeld, adding 133,000 stars.

The extension of this survey to the south pole was carried out in duplicate. Thome, at Cordoba, recorded the data for 580,000 stars from —23° to —61°, and others followed with 36,000 to the pole. In the zone —19° to —90°, Kapteyn has recorded similar data for 455,000 stars using photographic plates taken at the Cape Observatory. The southern survey includes stars to the 10th magnitude.

In these three *Durchmusterungen,* known as the "BD," "CD," and "CPD" the million stars are arranged by degrees in declination with ordinal numbers by right ascension in each degree, and these numbers have come into general use for indentifying the stars.

Astronomische Gesellschaft Catalogs. Having the systematized index of the stars as just described, the German astronomers, with coöperation by astronomers in various other countries, began observations about 1868, with transit circles, for fairly accurate positions of all stars to the 9th magnitude and many fainter. Eighteen observatories have coöperated in this work which has now extended over 70 years. The sixteen northern catalogs, +90° to —2° declination, were published by 1915; and the five from —2° to —23° by 1925. The rest of the southern sky has been covered by two observatories; Cordoba with the zones —23° to —47°, and —82° to —90°; and LaPlata with the zone —47° to —82°. Three of the Cordoba zones have been published, two are nearly completed, and the last one has been observed. Five of the LaPlata catalogs have been published, and the last one is being reduced.

The 16 northern catalogs contain 146,105 stars for the equinox 1875; and the 17 southern catalogs, 128,565 stars for the equinox 1900. The probable error of a position in these catalogs is around ±0″.4. The positions have been extensively used. Many of them are now over 50 years old, and proper motions are not given. They are referred to as the "AG" catalogs.

Reobservation of the AG Catalogs. Thirty years ago Schlesinger at Allegheny began experiments on the determination of star places by means of wide-angle doublet cameras photographing the three AG Zones, +2° to —2°, +50° to +55°, and +55° to +60°, using plates covering 25 square degrees of the sky. The result of this work showed the practicability of using large plates, and he recommended the reobservation by photography of all the AG catalogs.

From 1927 to 1939 the half of the sky between +30° and —30° declination was photographed at the Yale observatories, New Haven and Johannesburg, using plates covering 100 to 140 square degrees. Six catalogs covering the zones +30° to +20°, and —10° to —30°, have been published; the two for the zone —2° to —10° are expected next year; and the plates are measured and reductions started for five zones —2° to +20°. There will be 125,000 stars in all. Proper motions are given for all stars. These have been derived by comparing the Yale positions with the AG positions taken 40 or 50 years earlier.

For twenty degrees of this zone, as for the three earlier zones, reference stars were specially observed on several transit circles, but for the other forty degrees the reductions are being based on observations of all stars to 7.5 magnitude, with fainter stars in sparse regions, forming the regular programs at the Cape and Greenwich Observatories at the same epoch. The use of such observations for plate reduction was made possible by the fact that by the use of gratings the brighter stars produce measurable secondary images on the plates.

This is the first time any extensive photographic positions have become possible without special observations of the reference stars on other instruments. For the zone —20° to —30°, just published, there were 70 comparison stars per plate, and the final positions from two observations have probable errors of only ±0″.11. The systematic and accidental errors of the Yale positions are of the order ±0″.1 to ±0″.2, and of the annual motions ±0″.005 to ±0″.010.

A forceful illustration of the economy in such work is shown by the fact that the Yale Observatories single handed have reproduced one half the sky in some 20 years, whereas eleven observatories took 40 years to cover the same zone visually. In addition, the Yale Catalogs give proper motions for all stars. Much of the Yale reduction has been expedited by use of the punch card computing machines.

From 1929 to 1931 the northern half of the sky was photographed using plates covering 25 square degrees each, by coöperation of six German observatories and the Pulkowa Observatory in Russia, and simultaneous observations of 13,750 reference stars and the fundamental stars were taken on their transit circles. The reductions are based rigidly on the new fundamental system FK3, and proper motions for all stars are to be given. This work was largely completed when Pulkowa was destroyed.

Cape is continuing this work to the south pole, observing their own reference stars. The 24,000 stars in the zone —30° to —40° taken on 5° × 5° plates are nearly reduced. In the zone —40° to —52° the positions of 41,000 stars, all to magnitude 9.5, have been obtained from the Cape astrographic coördinates, with two sets of plates some 30 years apart furnishing the motions. Over 10,000 reference stars were observed for these zones.

Astrographic Catalogs. As an outcome of a conference of leading astronomers at Paris, photographic observations of all stars in the sky to the 14th magnitude were commenced about 50 years ago, using 13-inch telescopes with plates covering four square degrees each. The plan was to publish rectangular plate coördinates for all stars to the 11th magnitude and charts for all to the 14th magnitude. The catalogs will give coördinates for over a million stars, and several million will be charted. Eighteen observatories have coöperated in this great work and something like 160 catalogs have been completed covering five sixths of the sky. For several zones equatorial coördinates have also been published, some of these only for stars to the 9th or 10th magnitude. The zone —13° has just been received from Tacubaya, and the zone —57° from Sydney. The work is now going on to completion.

The original plan included simultaneous meridian observations of the reference stars, and several lists of 8,000 to 10,000 stars have been observed. But this has been possible for only a few zones, much of the reduction has been based on comparison star places taken from the AG catalogs of earlier epoch and without proper motions. New positions and motions of all the AG stars are now becoming available, and it will soon be possible to revise all the astrographic coördinates using more nearly accurate places of comparison stars. Schlesinger and Barney have shown that using the new Yale positions for the comparison stars the probable errors of astrographic places may be reduced from $\pm 0''.50$ to $\pm 0''.25$.

The Commission of the International Astronomical Union, having the coördination of this work in charge, submits various suggestions for making the results generally useful. One of these is the conversion of the rectangular to equatorial coördinates for all stars to the 9th or 10th magnitude; another suggestion is to determine motions, possibly by repeating the plates.

Other programs in which numerous observatories have taken part include: 5,000 Eros stars, (15 observatories); 3,000 zodiacal stars, (12); 3,000 standard stars, (12); 1,500 fundamental stars; stars in the Kapteyn areas; observations for variation of latitude are being carried on regularly at 12 observatories; and standard time is being determined and broadcast by 18 observatories; and so on. The French observatories had partly completed observing a list of 5,000 faint stars along the galactic plane when interrupted by war conditions. Seven or eight Russian observatories started work on a plan for determining absolute proper motions, and the precession, by observing some 700 extragalactic nebulae photographically referred to a list of 17,500 distant faint red stars with small motions and spaced ten to each 25 square degrees. The faint stars were to be connected to the present fundamental system through 930 intermediary stars. Quite a large number of observations had been made when several of the observa-

tories became devastated.

Since its removal to the present site in 1893 the Naval Observatory at Washington has published eight catalogs of standard and intermediary stars, and two more are being completed. These give on an average a catalog of 4,000 stars every five years. And the more tedious observations of the sun, moon, and planets continue regularly, often on two instruments.

Greenwich and Cape have just completed the observation of all stars in the sky to the 7.5 magnitude, and for much of the northern sky to the 8th and 9th magnitudes. Their three catalogs from +24° to —90° are awaiting publication. These, and two similar catalogs now under observation at Washington, contain spaced lists of brighter stars sufficient for reduction of large photographic plates. They also form a part of a general plan to keep all stars to the 8th magnitude under observation. Greenwich has averaged a catalog every seven years for 200 years.

The probable error of an observation on a standard instrument is less than ±0″.3, or for the mean of eight or ten observations ±0″.1. Systematic errors of ±0″.3 are not unusual.

Reduction of Old Work. Many of the old observations were poorly reduced, or reduced with inaccurate reduction constants, and some have never been reduced. Bessel used 9″.648 for the nutation constant in deriving his "Fundamenta," and later determined the value 8″.977 for his "Tabulae." The true value is 9″.21. He also found 20″.255 for the aberration as against 20″.47 now in use. Poor star places and wrong obliquities were used in reducing old observations of the planets. Bradley's observations were reduced by Bessel 60 years later, and reduced again by Auwers 130 years later. Hornsby's observations, 1774-1798, have just been rereduced. The observations by Groombridge in 1810 were rereduced 100 years later; and the Washington zones, 1846, were rereduced in 1916, and many other rereductions have been necessary to get the earlier observations uniform with later ones for use in proper motion work, in the construction of fundamental catalogs, and especially in planetary work.

Experience has shown that it takes several times as long to reduce and publish observations in final catalog form as it does to make the observations. We may estimate ten men a year to produce a catalog of 1,000 stars, and we can well agree with Newcomb, "The determination of positions of the fixed stars by meridian observations has formed a large fraction of the work of the leading observatories since 1750." It may seem regrettable that a man of Bessel's ability should have spent twelve years in making 75,000 observations of faint stars when photographic plates could have charted them in one year, had they been in use.

However the great efficiency of punched card machine methods as

applied by W. J. Eckert to mass production of routine astronomical reductions gives promise that observers will be relieved of much of the heavy computations in the future. Already a considerable amount of the reductions of the meridian work at the Naval Observatory is being carried on this way, with the coöperation of Dr. Eckert. Modern calculating machines are also used extensively.

Present Work. Now with large plates furnishing accurate positions of all fainter stars, the number of stars required to be observed on meridian instruments for plate reduction is reduced to some 50,000, or a star for each square degree, and this reduces this task of the transit circles to one-tenth that contemplated for them 50 years ago. Meridian observers welcome heartily the assistance given by photographic processes, with the prospect that the great mass of faint star work may be cared for in that way, and with the hope that more time may now be spent on the fundamental work, improving the positions and motions of the brighter stars, the planetary tables, and the astronomical constants.

The recommendation of the Commission on Meridian Astronomy of the I.A.U. is to keep under constant observation the 1500 fundamental stars, together with the sun, moon, and planets, and some 50,000 standard stars well spaced in the sky and including most stars brighter than the 8th magnitude. Based upon the standards the larger photographic plates will furnish positions for all stars to the 9th or 10th magnitude, and these in turn in successive photographic steps will reach to the faintest stars, and to the spirals. In this way star places will become far more nearly uniform and accurate by being based upon the same system and upon a standard system.

Geschichte des Fixsternhimmels. Investigators of star positions and motions such as Auwers, Boss, and others, have spent a large amount of time in searching the old catalogs, coördinating and rendering their results more accessible to others. In order to save such labor to others the Prussian Academy is collecting all the meridian observations made before 1900, as recorded in some 440 catalogs, reducing them to the common equinox 1875, and publishing the results in 48 volumes, one volume for each hour of right ascension for each half of the sky. The 24 volumes for the northern sky and the first five for the southern sky are now published. Considerably over half a million observations of 170,000 stars are given for the northern half. There will be a smaller number in the southern half, possibly 130,000 stars. These results are a great help in proper motion work, and, having them, computers do not require the old catalogs, many of which are rare. The publication is referred to as the "GFH."

Index of Star Places. All published catalogs from 1900 to 1925 have been indexed by Schorr in two large volumes, one for each half of the sky. The Index does not transcribe the positions, as is done in the

GFH, but gives the catalog number of the star wherever it occurs in the 400 catalogs, containing 365,000 star places observed during this period. The plan is to extend the Index every 25 years.

A list of 70 additional catalogs up to 1933 has been given by Kopff, and there have been many catalogs since. Adding the 160 astrographic catalogs, we see that observers since Bradley's time have accumulated over 1,100 catalogs containing positions of several million stars. And to this we must add 100,000 observations of the sun, moon, and planets. Some of these catalogs have but few stars, such for instance as a catalog by Gauss in 1827 with 43 stars, many have from 5,000 to 10,000 stars, and a number of the zone catalogs have over 40,000 stars.

Fundamental Catalogs. The combination of observational catalogs into compiled or fundamental catalogs is the next important step in the development of star places. The pioneer in this was Bessel who first reduced Bradley's observations and then, comparing them with observations taken 50 years later, deduced the proper motions and mean positions. Several compiled systems were used during last century but the three most important systems were developed by Newcomb, Boss, and Auwers, each developing his system in two or three successive steps.

Newcomb's right ascensions of 32 "Equatorial Fundamental Stars," (1872), was extended later to "1098 Standard Stars," and about 1900 his "Fundamental Catalog" of 1257 stars was published, based upon a thorough discussion of 43 independent observational catalogs, 1755-1895. The positions from this catalog were used in the national ephemerides until 1925, and they formed the basis of the revision of the observations of the sun, moon, and planets used by Newcomb, Hill, and Brown in their new tables.

Boss' catalog of "500 Declinations," (1877), was expanded into his catalog of "627 Standard Stars," and this became the basis of the "Preliminary General Catalog of 6188 Stars," (PGC), utilizing 80 observational catalogs from 1750 to 1900. This catalog has been a standard of comparison ever since its publication in 1910.

The AG catalogs were reduced using a system of standard stars determined by Auwers, (1870). Later by using 60 independent catalogs, 1750-1900, Auwers developed his New Fundamental Catalog of 925 stars, (NFK), which was used in the *Berliner Jahrbuch* from 1907 to 1940.

These three catalogs have formed the ground work of star places since 1900. However they have considerable accidental errors, and systematic errors increasing with the time. To improve the individual positions of stars in *The American Ephemeris,* Eichelberger compiled a catalog of "1504 Standard Stars," based largely upon four independent series of observations about 1910, and these places were used in the ephemerides from 1925 to 1940.

In forming the new "Catalog of 3539 Zodiacal Stars for the Equinox 1950," of the *Nautical Almanac* office, positions were taken from 90 catalogs, 1750-1930. The final positions in the catalog are on the basis of the FK3 system. The catalog is valuable in furnishing definitive positions and motions of stars well spaced over the zodiacal limits for reduction of observations of the moon and planets.

Boss designated his catalog of 6188 stars as "Preliminary" as he had plans for a much more extensive work, which, through the most generous support of the Carnegie Institution of Washington for over 30 years, has been carried to completion by Benjamin Boss and his associates. In this development 33,342 stars were observed at Albany and San Luis, and these results combined with 95 other independent catalogs, 1815 to 1930, have been formed into a new fundamental system. Based upon this system, observations from 238 catalogs, 1750-1930, have been combined into the new Albany "General Catalog of 33,342 Stars, for the Equinox 1950," (GC), recently published in five volumes.

The mean epoch of the positions in this catalog is around 1900, hence the catalog is already 40 years old. The right ascensions are affected by a pronounced periodic error increasing with the time. Corrections for this are given in the introduction. The equatorial declinations require a correction of $+0''.2$, and this will gradually increase.

The errors of the positions of the standard stars at 1950 are of the order $\pm 0''.1$ but for the larger part of the stars the errors run over $\pm 0''.3$, and errors of the motions are two or three times as large. With the large number of stars, and the fundamental nature of the work, this valuable catalog will be a standard of comparison for decades to come. It is recommended that all observational catalogs give, in their introductions, detailed comparisons with this catalog.

During the last 20 years Professor Kopff and his associates in a most exhaustive study of 80 independent catalogs, 1820-1930, have developed a revision of the NFK. This is known as the "Third Fundamental Catalog of the Berliner Jahrbuch," (FK3). It contains 1535 stars, and detailed explanations of the investigations are given in the *Astronomische Nachrichten,* and in the catalog itself. This system represents the most rigid fundamental system that has been developed. The errors of the positions for 1950 are of the order of $\pm 0''.1$, and the errors of the motions $\pm 0''.2$. Systematic corrections to these positions shown by recent Washington, Greenwich, and Cordoba observations hardly exceed $\pm 0''.2$.

This catalog has been recommended by the International Astronomical Union for use in national ephemerides, and in general as a basic system for future work. Through coöperation in the computations by the various national almanac offices the "Apparent Places of Fundamental Stars" is published annually in one volume by the British office,

commencing 1941. The volumes through 1944 have been issued, and those for 1945 and 1946 are assured.

Systematic Corrections to Catalogs. The various fundamental catalogs FK3, NFK, GC, PGC, N, and Ei have been thoroughly intercompared. Moreover in developing these the systematic differences from the system have been determind for a large number of individual catalogs. In proper motion work many other such comparisons have been made. In the introduction volume of the GC the detailed systematic corrections are tabulated for 238 observational catalogs, 1750-1930; the PGC gives corrections for 78 catalogs; the FK3 for 60; Roy for 46; and others are given in journals and, more recently, in the introductions to catalogs themselves. Less rigid comparisons are given for fainter stars by Batterman, for 67 catalogs with NFK; Fayet, for 161 with PGC; Hins, for 86 with PGC; and so on. With such helps one may take positions from almost any catalog and correct them to a desired fundamental system. The intercomparisons of the fundamental catalogs include the comparison of proper motions, and this is the case for a few individual catalogs, but in general published motions require reduction to the new systems.

Proper Motions. With the aid of the GFH, the Star Index, and other such helps, and the systematic corrections just described, observed positions of stars, with their weights, may be tabulated by epochs, and their proper motions derived, either by a least squares solution, as in definitive work, or by graphical methods, where mass production of less definitive nature is necessary. The repetition of zone catalogs such as the Yale reobservation of the AG zones, after an interval as much as 50 years in some cases, gives proper motions in large numbers by the simple comparison of the two series of observations.

The proper motion work by Porter of Cincinnati has been a notable contribution to the subject from this country. The Yale catalogs will yield 140,000 to 150,000 motions; Greenwich and Cape catalogs have 120,000 more; Pulkowa and Radcliffe have just published 40,000 motions in the Kapteyn areas, going down to 15th magnitude, using rectangular coördinates; and Luyten gives 90,000 from the Bruce survey of the southern sky; and so on.

Some 40 years ago Bossert collected 5671 motions from 36 catalogs. In 1936 Schorr in his "Proper Motion Lexicon" collected the motions for over 60,000 stars in the northern sky, and 34,000 in the southern sky from some 140 proper motion catalogs most of which have been determined in the last 50 years. And now the GC gives motions for 33,342 of the brighter stars all on one system.

In all catalogs up to the present proper motion has been defined as the total observed change in a star's position in excess of the computed precession. The reflex of the sun's motion relative to the stars—the secular parallax—and all motions of the stars themselves, such as star

streaming, or rotation, are included in the computation defined as proper motion. The solar motion and the systematic motions of the stars may be separated out if they follow analytical laws other than those of the precession.

One may well ask how all this information about star places and motions is being utilized. In the first place positional astronomers themselves are vitally concerned with the determination of the astronomical constants entering into the reductions of the observations, with the positions of the coördinate planes of reference used in these reductions, and also with the general motion in the solar system which are based upon the star places, and in turn help to determine them.

We observe from the earth and the motions which impress themselves upon us most are the daily rotation of the earth on its axis and the annual revolution of the earth around the sun. The planes of these motions, the equator and the ecliptic, are natural and convenient planes of reference having stable motions.

The fundamental coördinate system forms the basis of reference for the investigation of all events in space. We use it for determining the planetary motions and for all cosmic phenomena. There is no invariable point or plane to which we can tie the coördinates of the stars. We have therefore to set up a coördinate system with respect to the moving bodies by definition. A fundamental system may be regarded as the totality of a group of stars whose coördinates and their centennial variations define the positions of the equator and equinox at any time. The law of the precession, or motion of the planes among the stars, must be defined and its numerical value given. Professor Brown speaks of this as a moving frame of reference. Professor Boss considered that the problem of finding an invariable line of reference or direction in space is philosophically one of the most interesting problems which has been attempted in the whole range of science.

Catalogs give coördinates of the stars referred to positions of the equinox and equator for a given epoch, usually the beginning of a year near the mean epoch of the observations. The reduction of the observed apparent position to this mean position of the star as seen from the sun involves the use of aberration, nutation, precession, and annual parallax, and an assumed position of the coördinate planes. These are parts of the more general solar system problem, which is referred to here only in its bearing on our star work.

The position of the ecliptic is determined by observing the sun and planets.

The position of the pole of the equator is determined directly and quite accurately by observations of circumpolar stars. This is done in most standard programs. But the motion of the pole among the stars—the precession, with its complicated nutation, is due to the varying attraction of the sun and moon on the oblate rotating mass of the earth,

and gravitational theory furnishes the analytic expansion for this motion. However, the numerical values of the principal coefficients, the precession and nutation constants, are best determined from observations of the stars, over long periods for the precession, and over periods of 18 years for the nutation.

The constants in general use since 1900 were recommended by the Paris Conference in 1896. They are all slightly different from the values derived by Newcomb, and used by him in the planetary tables.

The Aberration is best determined from meridian observations of pole stars, and from latitude observations. Newcomb tabulated 34 results with a mean 20″.475, but in his tables he uses 20″.501 corresponding to his adopted solar parallax 8″.790. There have been quite a number of accurate observational determinations of this constant since 1900, varying from 20″.45 to 20″.55, the mean exceeding the value 20″.47 now in use. The recent Eros work gives 20″.507 as an adjusted dynamical value.

The Nutation constant is also best determined from meridian observations of pole stars, and from latitude work. Newcomb tabulated 27 determinations with a mean 9″.210, and several good determinations later ranging from 9″.206 to 9″.214 uphold this value. The value of this constant determined through dynamical relations from other observations is larger than that given by direct observation. Some explanation of this is necessary.

The Precession. Bessel was the first to make an accurate determination of the precession, and several good determinations were made last century. Using these, Newcomb adopted the general precession for 1850, 5023″.71, which was used in his tables of planets. The Paris Conference proposed that he redetermine the constant, which he did, using Auwers' proper motions of 3000 Bradley stars, with certain corrections. The new value 5024″.53, in general use since 1900, was used also in the construction of the fundamental catalogs of Newcomb, Boss, and Auwers, and it has been used in the two new systems, GC and FK3. Following Newcomb, Boss found a correction of +0″.85 to this value using the motions of 5400 stars in the PGC. These solutions contained terms for solar motion but not for stellar motions. It has since been shown that star streaming and galactic rotation affect such results. The effect of unequal distribution of the two Kapteyn streams changes Newcomb's equations in right ascension by 0″.56, and the effect of rotation appreciably changes the solution for precession.

Newcomb's solution was on the assumption of random motions of the stars. Dr. Jones calls attention to the fact that "the existence of two star streams, or a preferential direction of motion, or the rotation of the galaxy is not in accordance with the fundamental assumptions on which Newcomb's value of the precession was derived. The value obtained for the precession will depend upon the particular assumptions made."

Using the proper motions of 32,096 stars from the new General Catalog, Wilson and Raymond, in a most exhaustive examination, derived the correction +0″.94 to Newcomb's precession. Their solution included terms for solar motion and galactic rotation. It is on the basis of the GC system, but by applying the systematic differences, FK3-GC, to each of the equations representing the 108 areas of the sky, a correction to the precession was obtained on the basis of the FK3. Their final correction on this system is about +1″.00. Several others, using faint stars also, obtain similar results. Where the faint stars have been based on the GC system the results more or less repeat the standard. The Wilson-Raymond solution gives a consistent coördinated system of the constants for stellar motions, the precession, solar motion, and rotation. Other motions may be added later. As the values of these constants change as different groups of stars are used in solutions, by different computers, it might be well to avoid confusion by adopting for a working basis the constants as coördinated in the solution from the fundamental system.

Suggestions have been made that, as a means of avoiding the influence of stellar motions in determining the precession, the distant galaxies be used as a reference system having inappreciable motions. A program at Lick Observatory has this in mind, and the Russian observers have already started such a plan. The nebulae are poorly distributed and few are visible within 20° of the galactic plane. The observing steps will be liable to many errors. But eventually it may be possible to work inward from the galaxies as a fixed system, through relative motions to the faint and then to the bright stars of the standard system. The resulting precession should be quite independent of cosmic motions and should approximate its dynamical value. We could hardly expect definitive results along this line before the end of the century. In the meantime it may become possible to refer motions to distant stars in our own system. At the Allegheny and McCormick observatories and elsewhere bright stars are being compared with very faint stars near them.

Years ago Boss wrote, "Any question relative to a supposed rotation of the celestial sphere or any part of it, must depend in a very important degree upon the conclusion to be drawn relative to the accuracy of our standard catalogs upon which such computation must ultimately rest." And more recently DeSitter said, "It would certainly be premature to make a new determination either of the constant of precession, or of the elements of the planets before the present uncertainty regarding the systematic errors in the declination and the proper motions in declinations of the stars has been cleared up." The uncertainties in star places are much less now than when these cautions were given.

It has been shown that known systematic errors in the GC when

expressed in periodic form enter as small unreal terms both in the precession and in the rotation. Kopff cautions that the errors in the fundamental systems have great weight in the comparison with faint stars, as they may be comparable with the total motion of such stars. However, the errors of the FK3 system must be quite small.

Again, the positional astronomer is concerned with the general motions in the *solar system* which are based upon the star places. Before the true direction of a star may be determined at any time it is necessary to have a knowledge of the motions in the solar system, and in particular of the motion of the earth with which the observer is carried. On the other hand the planets may be observed only with reference to the stars around them from day to day, and the more accurately the stars are spaced the more exactly will the motions of the planets be determined. The process is one of successive approximation, first for the planetary motions, then for the star places. This is illustrated in history. The observations of Tycho Brahe in the sixteenth century permitted a solution of planetary motions by Kepler and his followers in the seventeenth century, which in turn made possible the accurate star observation results of Bradley and Bessel and their followers. From these came the tables and constants of Struve, Leverrier, Hansen, and others in the middle of the last century, forming the basis of observational work for the later part of the century and resulting in the great fundamental catalogs of stars by Newcomb, Boss, and Auwers. With these new positions of the standard stars the planetary observations of the last century were reconstructed into a great system of planetary and lunar tables and coördinated constants by Newcomb, Hill, and Brown. These new tables and constants have in turn made possible still more accurate star places, as exemplified by the two recent fundamental systems—GC and FK3. And upon these another solution of the planetary motions and revision of the constants are already under way. For four of the major planets all the old observations have now been reduced to the basis FK3, and new elements have been obtained for Mercury and Neptune.

The observations are tedious and the reductions exacting but the published results are milestones of progress in the unfolding of our system, and they form a record of the sun's long journey among the stars.

Last century the positions of the stars were used to define the motions of the planets; this century the proper motions are being used to build the structure of the *stellar system.* These cosmic motions form the subject matter of the new studies in stellar dynamics which were started on their way by Kapteyn's discovery of the two star streams in 1904. Besides determining the sun's motion among the stars the proper motions form the basic observational data for the study of cosmic motions in general. They are used to determine mean parallaxes,

cluster motions, star streaming, galactic rotation, space distribution, and so on. The subject is to be reviewed in this POPULAR ASTRONOMY series. Statistical and dynamical students are continually asking for more motions and for more accurate motions. This has encouraged mass production of less accurate motions by repetition of photographic plates at short intervals, with insufficient elimination of systematic and accidental errors. And we must caution that it has taken a century to build our basic motions accurately and it may well take another century to define accurately the basic cosmic motions.

The stars have a human interest also. The broadcasting of accurate standard time regulates the industries and commerce of the nations. Yesterday the stars and their signals guided merchant ships across the Atlantic and clipper planes over the Pacific. Today the same stars and their signals guide the Allied fleets around and over darkened Europe, and over the lone islands of the Pacific.

I like a sentence by Dr. Kopff, "We must continue to study the motions in the universe, both near and distant, more exactly and more in detail; and we are glad that we can go back to our star catalogs—often a little despised—as the foundation of our science."

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The Periodic Comet Holmes (1892 III)

By N. T. BOBROVNIKOFF

The recent unexpected increase in the brightness[1] of Comet 1942 *g* (Whipple) brings to mind another remarkable comet, designated 1892 III. It was so exceptional in its physical behavior that an hypothesis of the comet itself being the result of a collision of two unknown asteroids was seriously discussed.[2] Its orbit was also remarkable, being wholly included between the orbits of Mars and Jupiter, with the perihelion distance 2.12 and the aphelion distance 5.10 astronomical units. The eccentricity of its orbit, 0.38, made that altogether like an orbit of an asteroid rather than that of a comet.

The comet was discovered on November 6, 1892, by E. Holmes in London less than three degrees from the Andromeda Nebula which it exceeded in brightness. It was established later that the discovery occurred 145 days after perihelion. The comet until its discovery had been receding from the earth for several weeks and was projected in approximately the same point in the sky, but remained unnoticed.

The orbital history of the comet is very instructive showing how easy it is to lose a faint periodic comet. In 1892-93 the variations in its brightness drew attention of many astronomers, and more than 600 observations of its position are in existence. H. J. Zwiers devoted many years to the computation of its orbit.[3] For the apparition of 1899, he computed the perturbations not only by Jupiter and Saturn but also

by the Earth. The comet was re-discovered as Comet 1899 II. It was very faint (the maximum apparent brightness 13^m) and consequently was observed only with the largest telescopes. Zwiers' computations were so exact that the predicted time of perihelion passage required a correction of only 0^d.43 to reconcile the theory with observations. The comet was observed only 21 times, and Zwiers computed for the apparition of 1906 only the perturbations by Jupiter. The comet (1906 III) was observed by Max Wolf photographically only four times, and the last observation was very uncertain.

For the apparition of 1912, Zwiers published an ephemeris which was based on elements without any allowance for the perturbations. As was subsequently shown by Polak[4] the perturbations by Jupiter for this apparition were very large. The period increased by 0.47 years and the eccentricity diminished from 0.412 to 0.379. The increase in the period of revolution was the main cause that this comet was not found in 1912.

For the apparition of 1928, an ephemeris was furnished by the computing section of the British Astronomical Association. The comet was due at perihelion on March 22, 1928, but it was not favorably situated for the observers in the northern hemisphere. It was not found then, and there is little chance that it will ever be found again.

Three circumstance make this comet unique in the annals of astronomy. Some comets displayed one or two of these characteristics, but none possessed all three. They are: large variations in the apparent brightness at a heliocentric distance of almost three astronomical units; the character of its spectrum; and the formation of spherical envelopes around the nucleus.

The comet was not well observed in December, 1892, and in the first part of January, 1893. On January 16 Palisa,[5] in Vienna, found with the 27-inch refractor, instead of a diffuse comet of 10th or 12th magnitude as expected, a yellow star of 8th magnitude with an envelope 20″ in diameter. The comet increased in brightness by the next day and could be seen with the naked eye. After January 18 it began to decline in brightness, and by the beginning of April it became very faint.

Holetschek[6] found that the comet suddenly increased in brightness on January 16 by 9^m.1. This remarkable result cannot be accepted. The collation of all available photometric observations based on actual estimates of the brightness in comparison with the stars is given in Table 1. All observations have been reduced to a uniform Harvard system and aperture 2.67 inches, as explained in my previous papers.[7] The corrections (ΔH) are given in the sixth column of Table 1. The fifth column gives the observed magnitude, and the last column, the corrected magnitude. Observations are those of Backhouse,[8] Barnard,[9] Bigourdan,[10] Coit,[11] Gruss,[12] Holetschek,[13] and Kammermann.[14] It is seen that the total increase in brightness (Figure 1) amounted to only 2^m.8 and, furthermore, that the increase in brightness was by no means

sudden, as is seen from the observations by Backhouse on December 24 and January 10. Holetschek did not use Backhouse's observations and was apparently misled by a statement by Kobold (made after the increase in brightness) that on January 12 the comet was hardly visible in the neighborhood of a 10^m star. Holetschek assumed the comet's magnitude to be about 15, whereas considering the large negative correction for the 18-inch telescope used by Kobold, it was probably about 11^m, which agrees well enough with the description.

TABLE 1

BRIGHTNESS OF COMET HOLMES

No.	Observer	G.M.T.	Instr.	H′ m	ΔH m	H m
1	Barnard	Nov. 9.59	n.e.	5.4	+0.4	5.8
2	"	" 9.69	n.e.	4.5	+0.4	4.9
3	Backhouse	" 12.41	4′′5	4.8	−0.3	4.5
4	Barnard	" 12.84	n.e.	4.9	+0.4	5.3
5	Backhouse	" 13.25	n.e.	5.0	+0.4	5.4
6	"	" 13.25	bin.	5.0	+0.3	5.3
7	Bigourdan	" 13.44	n.e.	5.0	+0.4	5.4
8	Coit	" 13.54	n.e.	5.0	+0.4	5.4
9	Barnard	" 13.71	n.e.	5.1	+0.4	5.5
10	Backhouse	" 14.27	n.e.	5.1	+0.4	5.5
11	"	" 14.27	bin.	5.1	+0.3	5.4
12	"	" 14.58	n.e.	5.5	+0.4	5.9
13	Barnard	" 14.71	n.e.	5.3	+0.4	5.7
14	Backhouse	" 16.29	n.e.	5.5	+0.4	5.9
15	"	" 16.29	bin.	5.6	+0.3	5.9
16	Barnard	" 16.64	n.e.	5.0	+0.4	5.4
17	"	" 21.64	n.e.	6.0	+0.4	6.4
18	Backhouse	" 24.44	n.e.	6.1	+0.4	6.5
19	"	Dec. 11.35	n.e.	7.0	+0.4	7.4
20	"	" 11.35	bin.	7.0	+0.3	7.3
21	"	" 24.44	bin.	9.3	+0.3	9.6
22	"	Jan. 10.49	bin.	8.9	+0.3	9.2
23	Barnard	" 16.75	3″	8.0	−0.1	7.9
24	"	" 16.79	3″	7.9	−0.1	7.8
25	Kammermann	" 17.33	10″	7.8	−1.2	6.6
26	Backhouse	" 17.44	bin.	7.6	+0.3	7.9
27	Barnard	" 17.67	3″	7.9	−0.1	7.8
28	Gruss	" 18.25	8″	7.4	−1.0	6.4
29	Holetschek	" 20.33	1′′5	7.0	+0.2	7.2
30	Kammermann	" 20.33	10″	8.1	−1.2	6.9
31	Backhouse	" 20.40	bin.	6.9	+0.3	7.2
32	"	" 21.33	bin.	7.0	+0.3	7.3
33	"	" 21.49	bin.	7.0	+0.3	7.3
34	"	" 22.41	bin.	7.1	+0.3	7.4
35	Holetschek	" 23.33	1′′5	6.8	+0.2	7.0
36	Backhouse	" 23.40	bin.	7.3	+0.3	7.6
37	"	Feb. 4.33	bin.	7.9	+0.3	8.2
38	Holetschek	" 10.27	1′′5	8.4	+0.2	8.6
39	Backhouse	" 10.33	bin.	7.7	+0.3	8.0
40	"	Mar. 16.33	4′′5	11.5	−0.3	11.2

Figure 1 gives also the light curve of the nucleus based on Wendell's observations at Harvard.[15] Both curves show a nearly parallel run, but the increase in the brightness of the nucleus was apparently more abrupt and amounted to five magnitudes. This is in agreement

with the statement of all observers that on January 16 practically the whole light of the comet was concentrated in the nucleus. Wendell's observations have not been reduced to the same system as the observations for the total brightness. The correction due to the aperture of his instrument is uncertain owing to the fact that he used a special photometer. However, the curves at January 16 give a consistent result, and, therefore, the correction could not have been large.

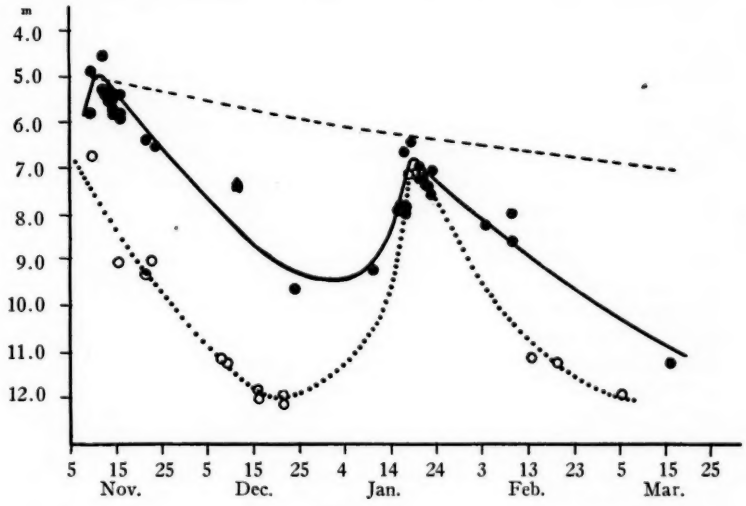

FIGURE 1

The variation in brightness of Comet Holmes November 9, 1892 to March 16, 1893. Filled circles represent total brightness, open circles represent the brightness of the nucleus. The general variation in total brightness is indicated by the solid line, that of the nucleus by the dotted line. The upper nearly straight line indicates the expected variation in total brighness due to the reflected light of the sun.

Finally, the upper, nearly straight line gives the variation in the brightness of the comet due to the reflected sunlight. It is adjusted to correspond to the brightness of the comet in early November.

It would seem that the variation in brightness was roughly periodic with maxima early in November and in the middle of January. The next maximum, however, would have fallen at the beginning of April, and it certainly did not occur. The comet was observed at Northfield[16] on April 2, and at Strassburg[17] on April 6, and it was exceedingly faint.

The apparent disagreement of observations for the same date may be due to the uncertainty in the estimates as well as to the actual variation in brightness within a short period mentioned by Barnard and

others.

It is impossible to find any law of variation in the brightness of this comet that would satisfy all observations. It is safe to assume that the comet was very faint prior to its discovery in November, 1892. According to Berberich the maximum theoretical brightness was attained on September 27, and on August 18 the comet should have been as bright as at discovery. An object a few degrees from the Andromeda Nebula and brighter than the nebula could not have remained unnoticed for three months. The discovery of the comet was undoubtedly due to its sudden increase in brightness comparable to that of the middle of January.

If we draw a line on Figure 1 parallel to the curve of the theoretical brightness through the observations of December 24 and March 16, we might consider it as representing the normal brightness of the comet. In that case the absolute brightness, H_0, of the comet (reduced to $\Delta = 1$, $r = 1$, on the basis of its light proportional to $\Delta^{-2}\ r^{-2}$) was $6^m.6$. This, however, cannot be reconciled with the observations of the beginning of April when the comet was very faint even in the large telescopes. If we assume that in April $H = 15^m.5$, the lowest value possible, we still get for H_0 in April $10^m.4$.

In 1899, however, the absolute brightness was $11^m.7$. In 1906 the photographic brightness results in $H_0 = 11^m.9$, but the visual brightness was undoubtedly much lower, as comets usually have a negative color index. The comet could not be seen at all in the Lick telescope.

We cannot escape the conclusion that the outbursts in 1892-3 so exhausted the cometary matter that the comet grew steadily fainter with each subsequent apparition. In other words the comet exists now probably in the form of a body indistinguishable from the faintest asteroids.

The spectrum of the comet was observed by Campbell,[18] Keeler,[19] v. Konkoly,[20] Vogel,[21] Ferrari,[22] and Lockyer[23] in November with the same result. The spectrum was practically wholly continuous with perhaps only the slightest suggestion of the carbon bands. The spectrum, therefore, was very different from that of most comets. At the outburst in January 16, the spectrum was observed by Wendell[15] on January 16 and by Kammermann[14] on January 17. The spectrum remained unchanged. Many observers emphasized the yellow or reddish color of the nucleus at the outburst.

The increase in brightness and the formation of a spherical envelope on January 16 under the eye of the observer is described in detail by Barnard:[9]

> "Between 6^h and 7^h I set for Holmes' comet with the 12-inch telescope, with little expectation to see it again on account of its faintness. A small, bright hazy star presented itself in the field . . . Thinking this could not be the comet, a second setting was made with the same result. Still uncertain, a series of measures was made to see if the object was in motion. The results showed that it was really the comet. At 9:55

> . . . in the finder of the 12-inch telescope it was 7.9 magnitude, and appeared like a small bright star—wholly indistinguishable from a star. At $10^h\,10^m$ it was certainly increasing in brightness. The nucleus could then be easily made out (in the 12-inch telescope) and was distinct though at first it was only suggested. . . At $10^h\,20^m$ there was no question that the nucleus was brightening; it had become very easy and seemed to have formed during the observations. . .
>
> "With the 36-inch telescope the appearance of the comet was the same as that on November 8 with the 12-inch. Its outline was quite definite, and the nucleus was pretty bright, central, hazy, and yellow, while the nebulosity was bluish. At $11^h\,0^m$ with the 12-inch telescope it was certainly brighter and the nucleus better seen."

It is evident that, although the comet was gradually growing brighter for several days, the most violent disturbance occurred on January 16. At about that time a mass of material was thrown off the nucleus in every direction, producing a uniform spherical envelope. This material was presumably dust, as it gave a wholly continuous spectrum. Since the ejection was in all directions, no disturbance of the orbital motion of the comet could be expected. L. Boss[24] found no evidence of any disturbance in the residuals of the position observations for this and following dates. It is interesting to note that the intersection of the radius-vector of the comet with the surface of the sun was very far from any sun-spots recorded for January 16 and preceding dates, and the connection of the outburst with the sun-spot activity is therefore unlikely.[25] The same conclusion is indicated by the list of magnetic storms[26] on the earth. The nearest storm before the outburst, and at that a very weak one, was recorded on January 5.

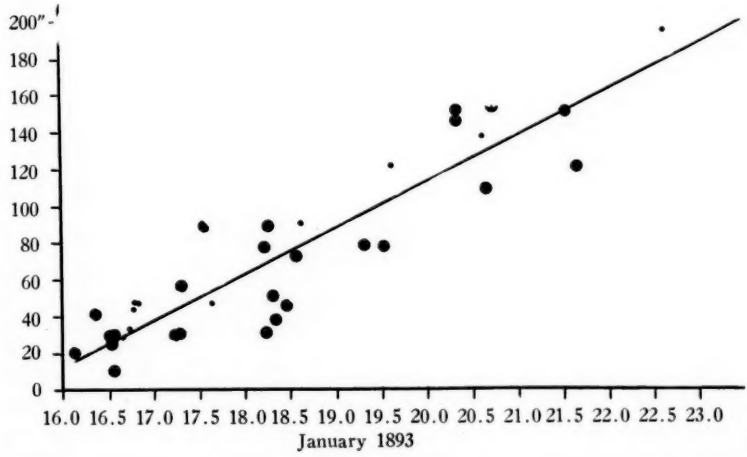

FIGURE 2

The expansion of the spherical envelope of Comet Holmes, January 16 to January 23, 1893. Dots represent the measures of the diameter by Barnard, filled circles by others.

The spherical envelope was expanding rather rapidly as was noticed by Barnard.[9] Besides his measures, those of Palisa,[5] Kobold,[27] Lovett,[28] Pechüle,[29] Wilson,[30] Hough,[31] Lamp,[32] Wendell,[15] Deichmüller,[33] Schorr,[34] Roberts,[35] and Ristenpart[36] are available for the period of January 16 to January 22. After the latter date the outlines of the envelope became too indefinite for any reliable measures.

TABLE 2

MOTION OF MATTER NEAR NUCLEUS JANUARY 16-22, 1893

No.	G.M.T. Jan.	Diameter	Observer	Place
1	16.184	20″	Palisa	Vienna
2	16.369	41	Kobold	Strassburg
3	16.551	25	Lovett	Charlottesville
4	16.558	30	Pechüle	Copenhagen
5	16.572	30	Wilson	Northfield
6	16.585	10	Hough	Evanston
7	16.677	29	Barnard	Mt. Hamilton
8	16.743	32	"	"
9	16.771	44	"	"
10	16.780	47	"	"
11	16.819	47	"	"
12	17.258	30	Lamp	Kiel
13	17.291	30	Pechüle	Copenhagen
14	17.305	56	Kobold	Strassburg
15	17.578	90	Wendell	Cambridge, Mass.
16	17.631	46	Barnard	Mt. Hamilton
17	18.210	30	Deichmüller	Bonn
18	18.235	78	Palisa	Vienna
19	18.259	87	Schorr	Hamburg
20	18.322	50	Kobold	Strassburg
21	18.333	39	Roberts	London, photo, reflector
22	18.483	45	Ristenpart	Karlsruhe
23	18.567	71	Hough	Evanston
24	18.622	90	Barnard	Mt. Hamilton
25	19.316	78	Kobold	Strassburg
26	19.519	76	Hough	Evanston
27	19.618	121	Barnard	Mt. Hamilton
28	20.333	145	Roberts	London, photo, reflector
29	20.347	150	Palisa	Vienna
30	20.615	136	Barnard	Mt. Hamilton
31	20.662	108	Wendell	Cambridge, Mass.
32	21.551	120	Wilson	Northfield
33	21.631	150	Wendell	Cambridge, Mass.
34	22.646	195	Barnard	Mt. Hamilton

These data are given in Table 2. They are plotted in Figure 2. Although there is considerable scattering of values of the diameter, it is seen that the increase was uniform over the period of six and a half days. The variation in the geocentric distance between January 16 and 22 was not enough to distort the curve. There is no appreciable systematic difference in the estimates of the diameter made with different telescopes. It is seen from Figure 2 that Barnard's measures (denoted by dots) are the most consistent as might be expected, since Barnard made a special effort in measuring the diameter of the comet.

Table 3 gives the thirty-four observations of Table 2 organized into

ten normal places. The columns marked D and p.e. give the observed diameter with its probable error; column Δ the geocentric distance of the comet,[37] and columns D_Δ and p.e. give the diameter reduced to the distance $\Delta = 1$ with the corresponding probable error.

TABLE 3

EXPANSION OF ENVELOPE

January 16-22, 1893

Normal Places

N.p.	No.	G.M.T.	$t-t_o$	D	p.e.	Δ	D_Δ	p.e.	o—c
I	6	16.470	0.470	26″	2″.9	2.380	61″.9	6″.9	+ 6″.1
II	5	16.758	0.758	40	2.6	2.384	95.4	6.2	+21.6
III	3	17.285	1.285	39	5.9	2.393	93.3	14.1	—13.4
IV	2	17.604	1.604	68	14.9	2.398	163.1	35.8	+36.5
V	5	18.272	2.272	57	7.3	2.408	137.3	17.5	—31.1
VI	3	18.557	2.557	69	8.8	2.413	166.5	21.2	—19.7
VII	3	19.484	3.484	92	9.9	2.427	223.3	24.0	—20.8
VIII	4	20.489	4.489	135	6.3	2.442	329.7	15.4	+22.8
IX	2	21.591	5.591	135	10.2	2.459	332.0	25.1	—43.7
X	1	22.646	6.646	195	....	2.476	482.8	....	+41.2

We can represent the uniform increase, V, in the diameter by a formula:

$$D = D_o + V\,(t - t_o)$$

where t_0 is arbitrary. Assuming t_0 to be January 16.000, we have for $t - t_0$ the values given in the fourth column of Table 3.

Solving for V and D_0 by the method of least squares, we find

$$V = 62''.5 \pm 3''.4$$

which represents the increase in the diameter of the comet per day reduced to the distance $\Delta = 1$. Converted into km/sec, we have

$$V = 0.54 \pm 0.03 \text{ km/sec.}$$

The radial velocity of expansion, v, is therefore:

$$v = 0.27 \pm 0.01 \text{ km/sec.}$$

The date of the beginning of expansion is obviously when D is equal to zero, or $D_0 = V\,(t_0 - t)$. Since from the least squares solution $D_0 = 26''.37$, the expansion started 0.894 days before the chosen origin of time, or on January 15.106 G.M.T.

The velocity of expansion probably was not uniform over small intervals of time. The scattering of measures after January 16 is of no particular significance as the envelope was getting diffuse. However, on January 16 Barnard described it as sharply defined, and yet from his five measures on this date, the following radial velocities of expansion can be derived:

TABLE 4

VELOCITY OF EXPANSION FROM BARNARD'S MEASURES

January 16

Time between		v	
8:15	9:50	0.45 km/sec	expansion
9:50	10:30	3.60 km/sec	expansion
10:30	10:43	7.16 km/sec	expansion
10:43	11:14	0.23 km/sec	contraction

The expansion therefore may have proceeded in a series of pulsations rather than in a strictly uniform manner.

From the last column of Table 3, which gives the residuals o — c of the diameter of the comet reduced to $\Delta = 1$, it is seen that the general character of the velocity over the whole period of observation was uniform. The residuals are of the size of probable errors of the normal places, and there is no evidence of a systematic departure from the straight line. The average probable error of the normal places computed from the combination of individual observations is 18″.5. From the least squares solution the probable error of one normal place of weight unity is 21″.1. The agreement is so good that we are justified in assuming that the straight line represents perfectly the increase in the diameter of the comet.

The analogous phenomenon of the expansion of a spherical envelope occurred also early in November, but the data are not available for the determination of the velocity of expansion. If we accept Barnard's measures of the diameter of the envelope on November 8, which give for November 8, 8:00 P.S.T. 260″, and for 9:40 P.S.T. 286″, the velocity of radial expansion is

$$v = 1.52 \text{ km/sec},$$

that is, some five times as large as found for January. The envelope was not very sharply defined, and this figure would indicate only the order of magnitude of the velocity.

On the other hand, Hough gives the diameter of the nucleus for the period January 19 to January 30 indicating slow but continuous expansion. From his data the average velocity of radial expansion was 2″.2 per day, that is, 0.05 km/sec, about one-fifth of the velocity found for the envelope in January.

The formation of spherical halos around cometary nuclei is a rare phenomenon observed only in a few comets. Their explanation involves many difficulties from the theoretical point of view as was discussed by me in detail in a previous paper.[38] The most remarkable result is that the radial velocity of expansion comes out very much the same for different comets.

References

[1] See the author's article, Popular Astronomy, **51**, 481, 1942.
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PERKINS OBSERVATORY, SEPTEMBER 2, 1943.

Tables for Moduli and Parallaxes and Magnitudes of Double-Star Components

By FREDERICK C. LEONARD

The two short tables that follow may prove to be convenient, particularly in the field of double-star astronomy. Table 1, entitled "Moduli and Parallaxes," gives, in the first, second, and third columns, headed respectively N_1, N_2, and N_3, the values, by tenths, from —10.0 to +4.9, of the modulus

$$N = 5 + 5 \log \pi'',$$

where π'' is the parallax of a star in seconds of arc. The quantity N is the amount that must be added to the apparent magnitude, m, of a star, to get its absolute magnitude, M, in accordance with the well-known relation

$$M = m + 5 + 5 \log \pi'' = m + N.$$

In the fourth column (π) of the table are listed the values of the parallax that correspond to the values of the modulus contained in the next preceding (the third) column (N_3). The values of the parallax that correspond to the values of the modulus in the first and second columns (N_1) and (N_2) may be found directly from the values of the parallax enumerated in the fourth column (π), simply by shifting the decimal point so that but one or two significant figures are present in

the value of the parallax that corresponds to the value of the modulus in the first column (N_1) or in the second column (N_2), as the case may be; *e.g.*, while π for N_3 of +2.6 equals 0".331, π for N_1 of —7.4 equals 0".003 and π for N_2 of —2.4 equals 0".033.[1]

In Table 2, "For Computing the Magnitudes of the Components of Double Stars," Δm is the difference in magnitude[2] between the components and C is the amount, correct to the nearest tenth of a magnitude, that must be added to the combined magnitude, m, of the pair, to obtain the magnitude m_1 of the brighter component. The magnitude m_2 of the fainter component is equal obviously to $m_1 + \Delta m$.[3]

TABLE 1

MODULI AND PARALLAXES

N_1	N_2	N_3	π	N_1	N_2	N_3	π
—10.0	—5.0	0.0	0".100	—7.5	—2.5	+2.5	0".316
— 9.9	—4.9	+0.1	.105	—7.4	—2.4	+2.6	.331
— 9.8	—4.8	+0.2	.110	—7.3	—2.3	+2.7	.347
— 9.7	—4.7	+0.3	.115	—7.2	—2.2	+2.8	.363
— 9.6	—4.6	+0.4	.120	—7.1	—2.1	+2.9	.380
— 9.5	—4.5	+0.5	.126	—7.0	—2.0	+3.0	.398
— 9.4	—4.4	+0.6	.132	—6.9	—1.9	+3.1	.417
— 9.3	—4.3	+0.7	.138	—6.8	—1.8	+3.2	.437
— 9.2	—4.2	+0.8	.145	—6.7	—1.7	+3.3	.457
— 9.1	—4.1	+0.9	.151	—6.6	—1.6	+3.4	.479
— 9.0	—4.0	+1.0	.158	—6.5	—1.5	+3.5	.501
— 8.9	—3.9	+1.1	.166	—6.4	—1.4	+3.6	.525
— 8.8	—3.8	+1.2	.174	—6.3	—1.3	+3.7	.550
— 8.7	—3.7	+1.3	.182	—6.2	—1.2	+3.8	.575
— 8.6	—3.6	+1.4	.191	—6.1	—1.1	+3.9	.603
— 8.5	—3.5	+1.5	.200	—6.0	—1.0	+4.0	.631
— 8.4	—3.4	+1.6	.209	—5.9	—0.9	+4.1	.661
— 8.3	—3.3	+1.7	.219	—5.8	—0.8	+4.2	.692
— 8.2	—3.2	+1.8	.229	—5.7	—0.7	+4.3	.724
— 8.1	—3.1	+1.9	.240	—5.6	—0.6	+4.4	.759
— 8.0	—3.0	+2.0	.251	—5.5	—0.5	+4.5	.794
— 7.9	—2.9	+2.1	.263	—5.4	—0.4	+4.6	.832
— 7.8	—2.8	+2.2	.275	—5.3	—0.3	+4.7	.871
— 7.7	—2.7	+2.3	.288	—5.2	—0.2	+4.8	.912
— 7.6	—2.6	+2.4	0".302	—5.1	—0.1	+4.9	0".955

TABLE 2

FOR COMPUTING THE MAGNITUDES OF THE COMPONENTS OF DOUBLE STARS

Δm	C
∞ to 3.22	0^m.0
3.21 to 2.12	0.1
2.11 to 1.45	0.2
1.44 to 1.08	0.3
1.07 to 0.71	0.4
0.70 to 0.47	0.5
0.46 to 0.21	0.6
0.20 to 0.02	0.7
0.01 to 0.00	0.75

NOTES

[1] A "Table for Absolute Magnitudes," by D. W. Hamlin and M. B. Wishard, which gives the values of the modulus for each 0".001 of the *parallax* from 0".001 to 0".100 and for every 0".005 from 0".100 to 0".500, constitutes Pt. 13 of *Ann. of the Dearborn Obs. of Northwestern Univ.*, **4**, 1943.

[2] Either apparent or absolute magnitude, if the components are physically related, since they have in that case practically identical parallaxes.

[3] Table 2 is merely an abridgment of more extensive tables that have been published elsewhere; *e.g.*, in *Ann. de l'Obs. Roy. de Belgique, N.S.*, **13**, 618, 1914.

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The Planets in January, 1944

By ALICE H. FARNSWORTH

NOTE: Greenwich Civil Time is used unless otherwise stated. To obtain Eastern Standard Time subtract 5 hours; Central Standard Time, 6 hours, etc. War Time in each zone is one hour later than Standard. Phenomena are described as seen from latitude 45° N. *The American Ephemeris and Nautical Almanac* is the source of the data.

Sun. The Sun, moving from its place in the constellation Sagittarius (α 18^h 41^m.4, δ —23° 6'.5 on January 1) into Capricornus (α 20^h 53^m.3, δ —17° 28'.3 on February 1), passes the descending node of the Moon's orbit on January 27. Two days earlier the Moon passes by, finds the Sun only two degrees west of the node (therefore well within the ecliptic limits) and totally eclipses it. The last time this constantly regressing node visited Capricornus (in January, 1925) many readers will recall that New York state and southern New England were treated to a marvelous view of the solar corona. On that occasion the three planets Venus, Jupiter, and Mercury were grouped together, west of the eclipsed Sun.

Moon. Phenomena are as follows:

		h	m
First Quarter	January	2	20 4
Full Moon		10	10 9
Last Quarter		18	15 32
New Moon		25	15 24
Runs high	January	9	19
In apogee		14	0
Runs low		24	2
In perigee		26	11

On the 5th, libration is favorable on the limbs west of Mare Crisium and north of Plato.

Aldebaran is occulted on January 7, visible from northerly regions. On the morning of the 13th the Moon passes in front of Jupiter.

Eclipse. The first of three eclipse seasons in the calendar year 1944 opens about January 11 with the Sun's arrival 18° west of the descending node of the Moon's orbit. The New Moon of January 25 totally eclipses the Sun as seen from a track starting in the Pacific Ocean south of Mexico, continuing south of the Galapagos Islands, entering South America at Chiclayo in the northern coast-region of Peru, sweeping over the continent in a path roughly tangent to the 10°-south parallel in Brazil, leaving Brazil near Fortaleza in the state of

Ceara. Thence it crosses to Africa where the distance between the two continents is almost a minimum, enters Africa near Freetown in Sierra Leone, and ends in the western Sahara.

The northern limit for the accompanying partial eclipse includes Florida and parts of other Gulf states in the early morning, and west Portugal near sunset. Maximum duration is slightly over four minutes on the central line in central Brazil.

Two weeks later the Full Moon does not pass the Earth's shadow unscathed. About half the Moon's disk will pass through the northern portion of the Earth's penumbra on February 9.

Mercury comes to the perihelion point of its orbit January 3. Its velocity of revolution there is 36 miles per second, twice that of the Earth. It passes to the west side of the Sun on January 8, and reaches its greatest western elongation (25° 7′ from the Sun) in Sagittarius on January 31.

Venus, in waxing gibbous phase, decreases constantly in angular diameter as it draws in towards the Sun on the far side of its orbit. It is bright in the morning sky, passed by the waning crescent Moon on January 22.

Earth passes the perihelion point of its orbit on the 4th at 18^h. Since its distance from the Sun is only 1½ million miles less than average, no great increase in the Sun's apparent diameter is noted, no great amelioration of winter in the northern hemisphere, and no accentuation of summer in the southern.

Mars is easily recognized as the brighter, ruddy object in the constellation Taurus, slowing down for its western stationary point on the 10th. By the end of the month its apparent disk has a diameter only six-tenths its value two months ago, and its stellar magnitude is zero, precisely that of Saturn, 14° east of it in Taurus.

Jupiter continues its retrograde motion in Leo, slightly northwest of Regulus. It lies in the direct path of the waning gibbous Moon on the 13th (See Occultation Predictions, p. 557, for exact circumstances).

Satellite phenomena of interest occur on the nights of January 5-6 and 13-14. In the first case only two bright moons (I and II, west of the planet) will be visible between $4^h\,06^m$ and $8^h\,47^m$ (G.C.T.), Satellite III disappears into eclipse at $3^h\,25^m$, not to reappear from occultation until $10^h\,22^m$, and IV enters transit at $4^h\,06^m$ and takes $4^h\,41^m$ to cross the disk, egress occurring at $8^h\,47^m$. On the second date again only two satellites (I and III, to the east of Jupiter) will be visible. Satellite II enters eclipse at $3^h\,59^m$ and reappears from occultation at $8^h\,13^m$. Satellite IV disappears into eclipse at $5^h\,33^m$ and remains hidden until $10^h\,27^m$.

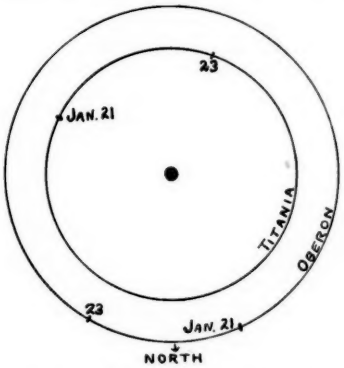
Saturn moves slowly westward in the eastern part of Taurus, its golden color distinguishing it from Mars and Aldebaran in the same constellation.

An inverting telescope allows the observer to look down upon the south side of the rings. The brightest satellite, Titan, which looks about like a star of the 8th magnitude takes approximately 16 days to complete an apparently clockwise revolution around the planet. It is visible in inferior conjunction, directly below Saturn, on the night of January 2-3, at greatest western elongation January 6-7, above the planet January 10-11, and at greatest eastern elongation January 14-15.

Uranus passes westward between 51 and ω Tauri, moving very slowly as it

approaches its stationary point. It will be found at $\delta +21°.1$, within half a degree of $\alpha\ 4^h\ 13^m$ throughout the month. The axis of the planet during these years is pointing so nearly towards the Sun (and Earth) that the planes of the orbits of its four satellites are seen in plan and the orbits themselves, described clockwise, appear essentially circular. It has been suggested* that a good eye with a good 8-inch telescope might hope to locate the two outer satellites, Titania and Oberon, estimated by Steavenson at $13^m.5$ and $13^m.7$.

Their positions relative to the planet on January 21 at 0^h, G.C.T. (a relatively moonless night) are shown in the diagram. Their distances from Uranus are



Positions of the two outer Satellites of Uranus for two dates in January, 1944.

32″ and 43″, respectively. In order to locate the satellites at any later time, allow for the following motions, *clockwise* in the orbits. (The tabulated figures are Mr. Marshall's.)

	Motion per day	Motion per hour
Titania	41°.36	1°.72
Oberon	26.74	1.11

As an illustration, positions are shown 48 hours later, at 0^h, January 23.

Neptune, stationary on January 6, may be located at $\alpha\ 12^h\ 17^m.5$, $\delta -0°.4$. It is still very close to η Virginis.

Reflecting on the status of the satellites in the solar system, one is newly led to the truth that mere bulk or mass is no true measure of interest or value. Ranging from the size of the planet Mercury to a chip the size of a mountain on the Earth, if chopped up so that the space could be economically used, they could all be contained in a sphere 1¼ times the diameter of Mars. We are to date aware of 28 of these bodies which circle the planets. Six of the seven which approximate or exceed the Moon in size revolve about giant planets (Jupiter 4, Saturn 1, Neptune 1); one major moon belongs to pigmy Earth. Fourteen more satellites approximate or exceed in size the *large* asteroids (2 more of Jupiter's, the 8 remaining of Saturn, and the 4 of Uranus). This leaves seven (the 5 outer-

*See R.K.M., The Most Difficult Satellites of Uranus, *Sky and Telescope*, October, 1943, p. 15.

most of Jupiter's and the tiny 2 of Mars) to be classed as resembling average or small asteroids in size.

The two satellites occupying positions in the solar system as regards their distances from the Sun are separated from their primary bodies (Earth and Neptune) by about the same amount of space, ¼ million miles. Uranus' four start at half this distance and end nearly twice as far out from their primary. Mars' whole system could quite comfortably be contained within either planet Neptune or Uranus. Appropriately perhaps, the most far-flung system is attached to the giant Jupiter, ranging from V, revolving at a distance half that of Earth's moon, to IX and XI distant 15 million miles (or a sixth of an astronomical unit) from the planet. These biggest orbits would easily encircle Earth and Venus when they are closest together. The extent of Saturn's group of attendants is about half as great, starting with Mimas at a distance comparable with Jupiter's V and ending with Phoebe, 8 million miles away.

Scientifically, the satellites have surely been important. One need only recall how Jupiter's bright satellites through variations in their times of eclipse spoke to Roemer of a finite velocity of light; how the secrets of mass and ellipticity of a planet stand revealed by a satellite's period of revolution and by the rate of revolution of its major axis, respectively; how satellites tell about each other's masses by their mutual perturbations; how certain midget moons far from their primaries provide stimulating exceptions to the general great rule of regularity in direction of motions in the solar system; how by systematic light-changes these moons challenge careful photometric investigation of their behavior and true nature. The list is not complete, but sufficient to prove our point.

Asteroid Notes

By HUGH S. RICE

This is an addition to the Asteroid Notes of the November issue, to which reference should be made. The five asteroids—Iris, Pallas, Vesta, Euterpe, and Ceres—have been under almost nightly observation by us lately. Usually all of them have been observed, one after another in the order named, on the same night. Nor has it been necessary to leave the apartment (which is in the Spuyten Duyvil section of this city and commands a fine horizon) in order to do the observing. The last four planets named have been observed from indoors looking out, contrary to the rules, but Iris is now so far toward the west that one has to move the Zeiss tripod out onto the fire-escape in order to effect a good view. Vesta and Euterpe are close together and Ceres is not far away; one need not move the tripod for these three. In fact, it was found easy to identify them by looking thru the closed windows; however, an enhanced view is obtained by opening the window and placing the tripod partly on the window sill.

IRIS has been observed as approximately 0.8 magnitude visually brighter than the predicted photo-magnitude. Its apparent path roughly south of Gamma and Eta Aquarii puts it in a good position for picking up. On November 26 it was estimated as of visual magnitude 9.2, and it is now becoming fainter. PALLAS is somewhat difficult because its entire retrograde loop lies in a region of faint stars; but with practice one learns the configurations of star triangles, beginning with Tau Ceti. Pallas has been found to be about 1.4 magnitudes visually brighter than the photo-magnitude, the visual magnitude being 8.2 on November 26. VESTA is always superb to follow. At the present time one starts with Aldebaran

for Vesta as well as for Euterpe. The visual magnitude on November 26 was 7.6, or 0.4 brighter than the predicted photo-magnitude. Its position (as well as that of each of the others) is so near the ephemeris position that no discrepancy can be found with the 50mm Zeiss binoculars. Watch for the close approach of Vesta to Aldebaran in the middle of December. Inasmuch as a continuation of the Vesta ephemeris is not yet at hand, the best observers can do is to follow the object before the given places run out, and mark the observed positions on a chart, and continue to follow the planet. EUTERPE, of visual magnitude 9.1 on November 26, is about 0.6 magnitude brighter than the photographic. On November 28 (U.T.) it was so close to a star of 8th magnitude as to make one object with 18 diameters. CERES is the next easiest asteroid after Vesta, the visual magnitude on November 26 (7.8) being 0.7 magnitude brighter than the photographic. The region in which the object appears is filled with stars and other objects.

ASTEROID EPHEMERIDES, 0^h U.T. EQUINOX 1943.0

	2 PALLAS			4 VESTA		
	α	δ		α	δ	
1944	h m	° ′	1943-44	h m	° ′
Jan. 1	1 11.5	−20 33	Dec. 12	4 37.5	+16 14
6	1 15.0	−20 1	17	4 32.3	+16 18
11	1 19.0	−19 26	22	4 27.4	+16 24
16	1 23.5	−18 49	27	4 23.1	+16 31
21	1 28.4	−18 10	Jan. 1	4 19.3	+16 40

	27 EUTERPE			1 CERES		
	α	δ		α	δ	
1944	h m	° ′	1944	h m	° ′
Jan. 1	4 29.5	+21 17	Jan. 1	5 58.4	+27 9
6	4 27.3	+21 19	6	5 53.4	+27 26
11	4 26.1	+21 22	11	5 48.8	+27 42
16	4 25.9	+21 28	16	5 44.6	+27 56
21	4 26.7	+21 36	21	5 41.1	+28 8

Hayden Planetarium, American Museum of Natural History, New York, New York, November 28, 1943.

Occultation Predictions for January, 1944

(Taken from the *American Ephemeris*)

Date 1944	Star	Mag.	IMMERSION Greenwich C.T.	IMMERSION a	IMMERSION b	IMMERSION Angle E from N	EMERSION Greenwich C.T.	EMERSION a	EMERSION b	EMERSION Angle E from N
			h m	m	m	°	h m	m	m	°
	OCCULTATIONS VISIBLE IN LONGITUDE +72° 30′, LATITUDE +42° 30′									
Jan. 1	ψ^1 Aqar	4.5	1 21.2	..	..	139	1 39.1	..	..	172
3	26 Ceti	6.2	2 36.8	−0.3	+2.5	9	3 13.9	−1.1	−3.4	301
5	μ Ceti	4.4	1 3.8	−1.5	+1.6	44	2 20.1	−1.9	−0.6	265
5	f Taur	4.3	21 11.1	−1.3	+0.6	118	21 53.1	0.0	+3.2	195
8	68 Orio	5.7	23 2.5	−0.7	+1.0	104	0 3.8	−0.5	+2.2	234
9	ν Gemi	4.1	9 24.4	−0.7	−0.2	52	10 7.9	+0.5	−2.5	318
12	X Canc	6.7	3 57.7	−1.7	−1.4	139	5 6.8	−2.1	+2.1	243
12	BD+17° 1979	6.3	5 12.5	−1.8	−1.9	139	6 28.0	−2.4	+1.0	250
13	Jupiter	−2.0	11 59.1	−0.3	−1.7	112	13 0.7	0.0	−1.7	289
15	308 B.Leon	5.9	1 58.2	0.0	+0.2	126	2 55.2	−0.2	+1.5	266
31	ξ^2 Ceti	4.3	22 48.3	−2.0	+0.1	86	0 3.5	−1.4	+1.2	222

	Occultations Visible in Longitude +91° 0′, Latitude +40° 0′											
Jan. 1	ψ^1 Aqar	4.5	0	50.4	−2.1	−1.8	110	1	38.1	−0.2	+1.8	195
3	26 Ceti	6.2	2	26.4	..	..	350	2	49.9	..	..	312
5	μ Ceti	4.4	0	35.9	−0.8	+2.9	24	1	40.7	−2.5	−0.4	280
8	68 Orio	5.7	22	54.5	0.0	+1.2	90	23	52.8	−0.1	+1.7	248
9	ν Gemi	4.1	9	10.5	−1.0	−0.9	80	10	16.1	−0.2	−1.9	290
12	X Canc	6.7	3	32.3	−1.4	−1.0	141	4	27.6	−1.1	+3.1	232
12	BD+17° 1979	6.3	4	45.0	−1.8	−2.5	152	5	37.2	−1.8	+3.8	227
13	Jupiter	−2.0	11	55.9	−0.5	−2.4	138	12	59.1	−0.7	−1.4	269
18	556 B.Virg	6.5	10	6.8	..	..	54	10	39.1	..	..	8
31	ξ^2 Ceti	4.3	22	11.7	−1.6	+1.5	66	23	32.2	−1.6	+1.3	237
	Occultations Visible in Longitude +120° 0′, Latitude +36° 0′											
Jan. 0	ψ^1 Aqar	4.5	23	48.6	−2.0	+0.8	73	1	7.6	−1.6	+1.0	230
6	75 Taur	5.3	23	35.6	−0.4	+0.5	117	0	16.9	+0.3	+2.7	206
9	16 Gemi	6.1	7	56.0	−2.5	+2.3	47	9	1.3	−1.7	−3.4	314
9	ν Gemi	4.1	8	31.4	−2.0	−1.8	116	9	52.0	−2.0	−0.1	249
11	d^1 Canc	5.9	14	41.3	+0.1	−1.6	117	15	36.9	+0.3	−1.1	272
12	X Canc	6.7	3	11.9	−0.2	0.0	128	4	2.6	0.0	+2.1	240
12	BD+17° 1979	6.3	4	11.0	−0.9	−1.1	145	4	53.9	−0.1	+3.3	224
18	566 B.Virg	6.5	9	16.5	−0.6	+0.6	110	10	25.6	−0.9	−0.1	303

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b*; apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

METEORS AND METEORITES

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

In the following table will be found the data on which to base results for the August Perseids in 1943. In the first place it will be noted that many familiar names are absent. This is due to several factors: the war with consequent absence from places where observations could be made, duties which prevented night work, and weather conditions. These last ruined the plans of many persons who wanted to observe and could not due to clouds. On the credit side, there is reason to believe that the press gave us wider support than usual as is proved by the distribution of reports from new persons. So, considering the handicaps, I feel that the Perseids had a proper amount of attention and that conclusion as to the relative density of the stream in 1943 can be safely drawn from the 4300± meteors reported. One interesting fact is that the percentage of reports by women was so much larger than usual. It was also heartening to us at headquarters to have some persons in writing actually thank us for calling the Perseids to their attention and saying how much they enjoyed their periods of watching!

The table is divided into two parts, the first with reports from people not in or connected with the A.M.S.; the second contains reports by members and helpers, or made directly under instructions by members. Looking over the table

certain facts stand out clearly, well-known indeed but worth repeating for the benefit of persons not familiar with meteors. Observing in or very near a city cuts down the rates terribly, as does any haze or moonlight. Whereas those who waited until the Moon had set, which was after true midnight on August 11/12, who were in the country, and had clear skies saw from 50 to 80 per hour in certain cases, persons who observed before moonset, near or in a city, and with hazy skies sometimes got as few as 2 meteors per hour! These latter doubtless felt great disgust at what A.M.S. headquarters had promised, though our prospectus was carefully and conservatively worded. They will probably believe that we grossly exaggerated the richness of the shower. But the facts are that not only were the Perseids in average abundance but also some very bright and striking ones appeared. Of course, only these latter were in general seen by the less fortunate observers, and even these meteors would have their brightness cut down by local conditions and so be much less spectacular. By averaging counts made under good conditions, we find that a partly corrected rate of 37 meteors per hour was attained on August 10/11; of 50 on August 11/12! and of 26 on August 12/13. So while the shower did not equal the 1909 return, for instance, it was quite up to the average. I have not yet worked up the radiants which may be expected from those mapped. These of course will only come from work done by our members. Of regional groups that under Professor Pruett in Oregon had outstanding success. Here in Pennsylvania, the weather was so unpromising that the usual groups were not out, and only isolated members observed, after it was found that the clouds had broken enough to justify work. Professor Braun of Salisbury, North Carolina, had a large group ready but pouring rain ruined his plans. He and one assistant saw only a few meteors in a brief clear interval. How many other groups were ready and had their plans spoiled by clouds is unknown, but R. M. Dole reports this to be true for him that he tried to observe on 18 nights between July 25 and August 25. The most interesting meteor plotted at Flower Observatory on August 11/12 was a fine —2, yellow Perseid, which left a train visible with a field glass for 25 seconds. The train quickly deformed and it will be possible to work out its projected direction of drift. This meteor was also seen by R. D. Boyd at Red Bank, New Jersey, who made a note of it saying that "it was nearly overhead in the north." Unfortunately he was not plotting and the position given is not close enough to justify computation. In the table, uncorrected rates to whole numbers only have been worked out where it seemed reasonably certain that the count was by one observer. It is impossible to work out comparable rates where two or more combine their counts. As the factor, F, is so small in many cases and not given in others, the corrected rates are not computed. Needed data are given, however, when available, so they can be readily derived. The dates preceded by a * are in July, all the rest in August. When possible, the standard time used by the observer is given; in all other cases it would be best to assume that the War Time for the locality in question was employed. We always request that the double date, as for instance August 11/12, be placed upon reports. In a few cases when this was not done there is ambiguity and I had to determine the date intended from other evidence in the report. For groups, only the leader's name is given unless each person made a separate count. In next to the last column is given the number of persons in such groups. The letter c in the last column denotes that the meteors were counted only; p that they (at least most of them) were plotted.

We are deeply indebted to the press all over the country for its generous

assistance, and also to each individual who took the time and trouble to make and report the observations we have been discussing. We sincerely hope that year by year these same people will continue to observe the Pereids and send us their reports whether they happen to see a request in the paper or not.

OBSERVATIONS OF METEORS IN THE PERIOD 1943 JULY 9 TO AUGUST 25

	Date	Began	Ended	Time Used	Min.	s →	F	Rate	Obs.	C
Binkley, Mrs. A. M., Florence, Ala.	10	15:00	15:30	C.S.T.	30	20	...	40		c
Bridges, R. P., Tempe, Ariz.	11	10:35	12:35	M.S.T.	120	22	0.5	11		c
" "		15:05	15:55		30	21	0.8	42		c
Lewis, Erma D., San Jose, Cal.	10	15±			8	10	...			c
Blaser, John, Fresno	12	9:30	10:30		60	12	...	12		c
Bostick, Dr. J. B., Fresno	11	14:10	14:40		30	25	...	50		c
Lee, Mrs. Conrad, Sacramento	11	14:05	15:05		60	69	...		3	c
Mitchell, Miss R. W., "	11	13:45	14:45	P.S.T.	60	61	...	61		c
Evarts, R., Ceres	11	13:00	14:00		60	37	...		2	c
Hurdle, Mrs. H. F., Yuba City	11	14:00	15:30		90	69	...	45		c
Lowe, R. W., New Hall	11	11:	12:00		60	54	0.5	54		c
" "		14:00	15:00		60	39	1.0	39		c
" "		15:00	17:00		60	11	...	11		c
Houghten, E. F., Lake Tahoe	11	12:10	13:40		90	15	...	10		c
Watson, J. F., Jr., Lodi	10	14:00	15:00	P.S.T.	60	62	...	62		c
Bogart, Miss S. L., Big Basin	11	13:00	14:15	P.S.T.	75	79	...		2	c
Hull, Miss B. S., Wallingford, Conn.	11	14:40	15:00		20	4	...	12		c
Bumpus, Miss., Belleville, Ill.	11	11:00	12:00		60	10	...	10		c
" "		12:00	13:00		60	10	...	10		c
" "		13:00	14:00		60	10	...	10		c
" "		14:00	15:00		60	22	...	22		c
Abell, T. W., Assumption	11	11:54	12:24	C.S.T.	30	14	0.4	28		c
Stall, Mrs. J., Lawrenceburg, Ind.	10	11:	14:		180	79	...		4?	c
" "	11	10:25	14:		215	38	...		4?	c
Anderson, F. O., Indianapolis	11	13:30	14:30		60	14	...	14		c
Johnson, M. Irene, Indianapolis	11	14:45	15:35		..	4	...			p
Wheeler, K. W., Purdue Univ.	11	12:20	13:20		60	14	0.4	14		c
Megill, Miss Esther, York, Kan.	11	13:30	14:30	C.S.T.	60	29	...	29		c
Plock, P. H., Baltimore, Md.	11	10:30	11:30		60	9	...	9		c
Pahl, H. B., Baltimore, Md.	11	14:30	15:30		60	30	0.8	30		c
Monteleone, Mario, Fullerton	11	15:00	16:00		60	59	...	59		c
Elliott, Mrs. T. H., Battle Creek, Mich.	11	12:00	13:45		105	40	...		2	c
Walker, Mrs. C. A., Roscommon	11	12:00	13:00		60	25	0.5	25		c
Sonnenburg, Thelma, Mt. Clemens	11	12:00	15:00		..	28	..			c
Pratt, Belle, Sauk Rapids, Minn.	11	14:30	16:30		120	42	1.0	21		c
Shepherd, Marjorie G., Camp Shelby, Miss.	11	13:30	14:00	C.S.T.	30	31	...	62		c
" "	21	8:25	9:00	C.S.T.	35	5	...	9		c
Brubeck, E. H., Scotts Bluff, Neb.	12	14:00	14:30		30	16	...	32		c
Wimmer, Mrs. C. E., Bayard	11	13:15	14:00	M.S.T.	45	23	...	31		c
Bender, Chas., Somerdale, N. J.	11	12:00	13:20		90	9	0.3	6		c
" "		13:30	14:00		30	14	1.0	28		c
Boyd, R. D., Red Bank	11	13:	14:	E.S.T.	60	31	1.0	31		c
" "		14:	15:	E.S.T.	60	46	1.0	46		c
Chlebrunkow, R., Paterson	11	12:	13:		..	2	...			c
Karsner, Mrs. J. R., Albuquerque, N. M.	11	13:50	14:50	M.S.T.	60	68	...	68		c
" "		14:50	15:50	M.S.T.	60	24	...	24		c
Keller, Ben, Albuquerque	11	13:52	14:52	M.S.T.	60	74	...	74		c

	Date	Began	Ended	Time Used	Min.	s →	F	Rate	Obs.	C
Keller, Ben, Albuquerque		14:52	15:52	M.S.T.	60	76	...	76		c
Karsner, Mary A. H., Albuquerque	11	13:50	14:50	M.S.T.	60	55	...	55		c
" "		14:50	15:50	M.S.T.	60	24	...	24		c
Keller, Jane, Albuquerque	11	13:45	14:45	M.S.T.	60	48	...	48		c
Hanabeugh, Mrs. E., Rhinebeck, N. Y.	11	12:10	12:55		45	8	...	11		c
Levy, H. W., Cedarhurst, L. I.	11	13:15	13:45		30	5	...	10		c
Kremer, A. Elizabeth, Valhalla	11	12:	14:		120	9	1.0	4		c
Zuidema, H. P., New York	11	10:	12:37	E.S.T.	..	10	...			c
Bryems, John, Little Switzerland, N. C.	11	13:	14:30		90	11	0.2	7		c
Huey, J. W., Jamestown, N. D.	10	12:55	13:20		25	10	0.5	24		c
" "	11	12:55	13:55		60	16	0.5	16		c
Butler, Margarte M., Egeland	12	10:30	11:00	C.S.T.	30	26	...	52		c
Talkington, Mrs. R., Warren, Ohio	11	12:25	14:00		95	43	...	27		c
McGrew, Harry, Sharonville	10	10:	11:		60	1	...			c
Russell, O. E., Rockford	11	14:00	15:00		60	24	0.9	24		c
" "		15:00	16:00		60	29	0.9	29		c
" "	12	14:00	14:35		35	7	0.4	12		c
Ingersoll, Bob, Oklahoma City, Okla.	10	13:00	16:00		180	40	...	13		c
" "	11	12:00	14:00		120	29+	...	15		c
" "	12	13:00	16:00		180	40	...	13		c
Hively, Ovid, Tulsa	12	15:38	16:25		47	55	...	70		c
Fisher, Donald, Jr., Huntingdon, Pa.	11				..	3	...			c
Stek, Frank, Olyphant	10	12:30	13:30		60	7	0.4	7		c
" "	11	12:	13:		60	7	...	7		c
Hardin, Billie, Elora, Tenn.	11	11:	12:		60	6	...	6		c
" "	12	12:	13:		60	14	...	14		c
Sanders, Robert, Dallas, Texas	11	13:00	14:00		60	13	...	13		d
" "	12	13:00	14:00		60	9	...	9		d
Horn, Rose Ann, Dallas	11	12:	13:		60	29	...	29		c
Cross, J. B., San Antonio	11	13:45	14:45		60	63	...	63	4	c
Kemper, Father, Kerrsville	10	14:15	15:00		45	7	...	9		c
Cooke, W. R., Lynchburg, Va.	11	8:	10:	E.S.T.	..	2	...			c
Patterson, Gertrude H., Newport, Vt.	11	14:00	15:15		75	22	...	17		c
Gerl, E., Wilbur, Wash.	11	9:45	10:30		45	10	...	13	2+	c
Bixley, Miss Dorothy, Ervay, Wyo.	11	12:35	13:05		30	12	...	24		c
Weitzenhoffer, K., New York, N. Y.	*30	10:00	15:00	E.S.T.	300	46	1.0	9		c
" "	1	14:05	15:05	E.S.T.	60	8	0.8	8		c
" "	5	12:50	15:00	E.S.T.	130	21	1.0	10		c
" "	6	9:40	13:00	E.S.T.	190	43	1.0	14		c
" "	6	13:00	15:30	E.S.T.	150	40	1.0	16		c
" "	7	9:	13:	E.S.T.	..	19	...			c
Ford, C. B. (1), Troy	11	13:15	14:15	E.S.T.	60	67	...	67	4	c
Ford, C. B. (2), Troy	11	13:15	14:15	E.S.T.	60	62	0.9	62	4	c
Braun, M. L., Salisbury, N. C.	10	15:45	16:45		60	9	0.4	9		c
" "	11	15:43	16:43		60	15	0.5	15		c
Withers, G. W., Jr., Spencer	10	12:00	13:30		90	2	?			c
" "	11	15:30	16:15		45	17	0.6	23		c
Johnson, H. M., Rochester	10	15:00	15:30	E.S.T.	..	3	...			p
" "	11	15:00	16:00	E.S.T.	60	18	0.5	18		p
Liller, Bill, Atlantic, Ga.	3	14:05	14:35	E.S.T.	30	7	0.5	14		p
" "	4	13:08	15:15	E.S.T.	127	28	0.7	13		p
" "	9	13:40	15:40	E.S.T.	120	27	0.9	14		p

	Date	Began	Ended	Time Used	Min.	s →	F	Rate	Obs.	C
Liller, Bill, Atlantic, Ga.	10	13:20	15:40	E.S.T.	140	34	0.9	15		p
" "	11					4	...			p
Leerman, J., Baltimore, Md.	10	13:45	14:45	E.S.T.	60	3	...	3		c
" "	11	12:45	13:45	E.S.T.	60	11	...	11		c
" "	14	15:45	16:45	E.S.T.	60	5	...	5		c
Roques, P. E., Los Angeles, Cal.	11	12:38	14:33	P.S.T.	115	26	1.0	14		p
Dole, R. M., Cape Elizabeth, Me.	25	9:00	11:00	E.S.T.	120	4	...	2		c
Jordan, Marvin, Joliet, Ill.	*28	10:00	11:00	C.S.T.	60	8	0.7	8		c
Preucil, Frank, Joliet, Ill.	*27	8:50	9:50	C.S.T.	60	14	0.8	14		c
Horton, W. P., Utica, N. Y.	*31	11:25	12:59	E.S.T.	94	16	1.0	10		p
Johnson, M. C., Des Moines, Iowa	*19	13:30	15:15	C.S.T.	105	5	0.3	3		p
" "	*21	13:10	15:10	C.S.T.	120	4	0.5	2		p
" "	*22	13:00	15:05	C.S.T.	125	7	0.6	3		p
" "	*24	13:00	15:00	C.S.T.	120	5	0.6	2		p
" "	*25	13:00	15:00	C.S.T.	120	17	0.7	8		p
" "	*27	13:00	15:00	C.S.T.	120	18	1.0	9		p
" "	*28	14:00	15:00	C.S.T.	60	9	0.9	9		p
" "	*31	13:05	14:15	C.S.T.	70	10	1.0	9		p
" "	9	13:00	15:00	C.S.T.	120	20	1.0	10		p
Reilly, Miss Edith F., Philadelphia, Pa.	11	12:00	15:00	E.S.T.	180	29	0.5	10		c
Woodburn, J. J., Philadelphia, Pa.	10	9:00	12:15	E.S.T.	..	19	...			c
" "	11	9:43	11:58	E.S.T.	..	11	0.3			c
Marshall, R. K., Cook Obs.	10	13:30	16:30	E.S.T.	134	21	0.6	10		c
" "	11	13:00	16:15	E.S.T.	195	93	0.6	29		c
Olivier, C. P., Flower Obs.	11	12:18	15:58	E.S.T.	174	77	0.5	26		p
Bailey, E. F., Brooklyn	*30	11:	12:15		75	15	...		3	c
Anderson, Paul E., Beechwood, Mich.	*9	10:50	14:35	C.S.T.	..	44	0.7			p
" "	*23	10:27	10:42	C.S.T.	15	1	0.9			p
" "	*27	11:45	13:00	C.S.T.	75	23	0.9	18		p
" "	*30	10:00	12:45	C.S.T.	165	51	0.9			p
Oregon Group reporting through Professor J. Hugh Pruett.										
White, Wm. R., Roseburg	10	13:50	14:50	P.S.T.	60	49	1.0	49		c
" "	11	14:15	15:15	P.S.T.	60	81	1.0	81		c
White, Bertha W., Roseburg	10	13:50	14:50	P.S.T.	60	55	1.0	55		c
" "	11	14:15	15:15	P.S.T.	60	80	1.0	80		c
White, Wm. A., Roseburg	10	13:50	14:50	P.S.T.	60	51	1.0	51		c
" "	11	14:15	15:15	P.S.T.	60	79	1.0	79		c
Pruett, J. Hugh, Eugene	11	14:53	16:23	P.S.T.	90	88	0.9	56		c
Pruett, Mrs. Hope, Eugene	11	14:53	16:23	P.S.T.	90	88	0.9	59		c
Thompson, Betty J., Eugene	10	14:00	15:00	P.S.T.	60	31	0.9	31		c
" "	11	13:55	14:55	P.S.T.	60	56	0.9	56		c
" "	12	14:10	15:10	P.S.T.	60	21	0.9	21		c
Thompson, Ferne, Eugene	10	14:00	15:00	P.S.T.	60	36	0.9	36		c
" "	11	13:55	14:55	P.S.T.	60	40	0.9	40		c
" "	12	14:10	15:10	P.S.T.	60	26	0.9	26		c
Wilhelm, Mary C., Eugene	9	13:00	14:00	P.S.T.	60	10	1.0	10		c
Bones, B. R., Grants Pass	11	14:50	15:50	P.S.T.	60	65	1.0	65		c
Black, Kitty, Lucky Boy Camp	9	13:00	14:00	P.S.T.	60	31	1.0	31		c
Sandmeyer, Eleanor, Buhl, Idaho	11	14:00	16:00	M.S.T.	120	160	1.0	80		c
Long, Mrs. Berta, Dell Rapids, S. D.	11	15:30	16:30	C.S.T.	60	20	1.0	20		c
Total					4298					

Flower Observatory of the University of Pennsylvania, Upper Darby, Pennsylvania, 1943 October 23.

Contributions of the Society for Research on Meteorites

Edited by FREDERICK C. LEONARD
Department of Astronomy, University of California, Los Angeles

President of the Society: LINCOLN LA PAZ, Department of Mathematics, Ohio State University, Columbus
Secretary of the Society: C. H. CLEMINSHAW, Griffith Observatory, Los Angeles, and Department of Astronomy, University of Southern California, Los Angeles

References on the Early History of the Tucson, Arizona, Meteorites: The "Irwin-Ainsa" and "Carleton" Irons

By P. J. McGOUGH
Flagstaff, Arizona

[*Continued from the November Issue*]

REF. No. 13, 1863, WHITNEY

The following was read by Professor J. D. Whitney, State Geologist, at a meeting of the California Academy of Sciences, in San Francisco, on July 20, 1863:

"Notice of the Large Mass of Meteoric Iron Now in this City on its Way to the Smithsonian Institution: By a singular coincidence, we have now the pleasure of seeing in this city the two great masses of meteoric iron which have so often been spoken of as being in Tucson, Arizona, one of which was brought here and presented to the city by General Carleton November last, and of which a notice has already appeared in our *Proceedings.* This mass may properly be designated as the *Carleton Tucson Meteorite,* while the other, which is destined for the Smithsonian Institution, may be called the *Ainsa Tucson Meteorite,* as it has been rendered accessible to scientific investigation by Mr. Santiago M. Ainsa. The [Ainsa] meteorite was first discovered by the early Jesuit missionaries in the mountains called the Sierra de Madera, near Tucson. In 1735, *El Capitán de las Provincias del Occidente,* Don Juan Bautista de Anza, induced by the account of the science-loving Jesuits, ordered the meteorite to be removed from the mountains, with the intention of sending it to Spain. However, through the want of wagon roads and proper means of conveyance, at that time, to take it to San Blas, the nearest port of entry, the attempt was abandoned. The meteorite was left at Tucson, where it continued to attract the attention of the scientific men who visited that country for over one hundred years. Since the acquisition of Arizona by the United States, greater notice has been taken of this meteorite, it having been mentioned several times in the official reports of the Government agents. By a singular coincidence, Augustin Ainsa, the great-grandson of Don Juan Bautista de Anza, undertook, in 1860, to transport the meteorite and present it to the Smithsonian Institution. With great difficulty it was brought as far as the Ynigo Hacienda, where it remained until 1863, when Jesus M. Ainsa, on his last visit to Sonora, brought it to this city with the intention of forwarding it to the Smithsonian Institution, where it will soon be sent. At present, the mass in question lies upon the steps of the customhouse, where it has most admirably been photographed by Mr. Watkins. It is said by Mr. Ainsa to weigh 1600 pounds. The shape of this meteoric mass is very peculiar, and at first it would

not be recognized as the identical one figured by Mr. Bartlett at Tucson, especially as this gentleman figured it to weigh 600 pounds only. Instead of being, as Mr. Bartlett supposed, a mass supported on two legs, it is in reality a ring of metal of very irregular dimensions, of which a fourth was buried in the ground in order to support it in a position convenient to use as an anvil, as, when it was seen by him in Tuscon, it was used for that purpose. The mass was shipped on the Panama steamer, which sails from here on August 3rd."

REF. No. 14, 1863, IRWIN

A letter from Dr. B. J. Irwin to Professor J. Henry, Secretary, Smithsonian Institution, dated September, 1863:

"I am in receipt of your letter of the 25th ult., by which I learn that the great Tucson meteorite is in a fair way of getting to Washington at last. I am sure that you will feel proud when you see it. I knew that the Carleton specimen was not ours, as I had it sent to Hermosillo before I left Arizona. That one sent by General Carleton is about 750 pounds, while ours is twice that weight. I believe that I have given you some data about the Tucson meteorite in a monograph published by the War Department in 1860, 'Medical Statistics of the U.S. Army, 1855 to 1860.' Sincerely, B. J. IRWIN, Surgeon, U.S. Army, Memphis, Tennessee."

REF. No. 15, 1865, CARLETON

A letter to the Smithsonian Institution from General James H. Carleton:

"Headquarters, Department of New Mexico, Santa Fe, New Mexico, August 23, 1865: Dear Sir: Last week I received from Dr. B. J. Irwin the inclosed pamphlet in regard to two aerolites [siderites] which were found near Tucson, Arizona, one of which you have in the Smithsonian Institution and the other [of which] I had the honor to present to the City of San Francisco. In speaking of these to His Excellency, Henry Connelly, Governor of New Mexico, he told me of one in Chihuahua surpassing in size either of these. I should like very much for the United States to secure possession of it. Sincerely, JAMES H. CARLETON, General, U.S. Army."

REF. No. 16, 1865, IRWIN

"History of the Great Tucson Meteorite Donated to the Smithsonian Institution," by Dr. B. J. D. Irwin, a pamphlet published by Dr. Irwin, protesting the claim that the Ainsa Brothers were the donors of the larger Tucson meteorite to the Smithsonian Institution. Following is a letter written by him under date of June 27, 1865, to Professor J. Henry, the Secretary of the Smithsonian Institution:

"To Professor J. Henry, Secretary, Smithsonian Institution: In tendering my obligations for a copy of the *Smithsonian Report for 1863,* I have the honor to call your attention to a gross injustice done to me in regard to the Tucson meteorite, which was donated by me to the Institution in December, 1857. I took post at Fort Buchanan, Arizona, and shortly afterward visited Tucson to examine the famous meteorite, which I found hidden away in an obscure alley. No person claimed it, and it was looked upon as a curious and valueless object. Having devoted much of my time during the preceding three years to collecting specimens of natural history for the Smithsonian Institution, I determined to make an effort to secure such a fine specimen for the collection at Washington. In my correspondence with Professor Spencer Baird, Assistant Secretary of the Smith-

sonian, I communicated my intentions of forwarding and presenting it to the Institution. Many Army officers and others looked upon my idea as being impracticable, owing to the difficulty of the transportation of such a heavy mass over the bad roads of the country. Professor Baird, however, approved of my design and, by way of encouragement, authorized me to contract for its expense [in being transported] to Guaymas. My correspondence on the subject is doubtless to be found in the records of the Institution. The opportunities to send such freight to Guaymas were very rare, as pack trains very seldom went that far, apart from which an ordinary wagon was not deemed sufficiently strong for the purpose; so I did not get the long-sought chance of dispatching it until in the winter of 1860 or the spring of 1861. Mr. Augustin Ainsa, who was engaged in the business of freighting and lived at the Fort during the three years I was there, entered into an agreement with me to transport it to Guaymas, for which I agreed to pay him $50, whence arrangements were to be made for its shipment to San Francisco, California. In the latter part of 1861, I arrived in Washington, where I met Mr. Ainsa, who informed me that he was unable to convey it farther than Alamito, near Hermosillo, where it would remain until an opportunity offered to have it sent on to Guaymas. These facts I communicated to Professor Baird. Some time ago I received a letter from him announcing the arrival of the meteorite and that it would have a conspicuous position in the Institution and that a plate would be placed upon it, giving a history of my donation. With these facts known to the officers of the Institution, I must be pardoned for saying that I have read with profound surprise and indignation the letter of Santiago Ainsa contained in the annual report, pp. 86-7, wherein, in the coolest manner and with the most embellishing effrontery, he takes upon himself, after declining to accept the freight charges for its transportation, the unwarrantable liberty of tendering it as a gift of himself and brother to the Institution! This conduct must be in keeping with the romantic history given by Mr. Ainsa's *grandmother* in regard to the exploits of the Great Captain of the Western Provinces, which doubtless is as pertinent to the true history of the matter as is the attempted imposition of Mr. Ainsa to an honest transaction; so I must be pardoned for my doubting the correctness of both! In my transactions with Mr. Ainsa for the transportation of the meteorite, he never evinced any knowledge of its history or interest in it beyond the pecuniary amount which he was to receive for carrying it to Guaymas. When it arrived in San Francisco, it attracted so much public attention that his brother took upon himself the responsibility of retaining it to satisfy the public curiosity and generously permitted the State Geological Society to help themselves to a portion of it! Then it flashed upon the minds of the Messrs. Ainsa that the crude mass of metal was an object of value and interest to scientific persons; so they liberally declined to accept the amount of the freight and with what magnanimity and generosity they politely requested its acceptance by the Institution as a donation from themselves! This was a great breach of trust on the part of those public carriers, consequent upon which I respectfully enter my emphatic protest against the meteorite's being received or known as the *Ainsa Meteorite*. I presented it and it is my donation. As the officers of the Institution have failed to recognize my services by bestowing my name upon it, it should be known as it was until I brought it within the reach of the scientific world; *i.e.*, as the *Tucson Meteorite*. The fact that Mr. Ainsa had it carried by [for?] me a certain distance is no valid reason why it should bear his name. Truly I am surprised and disappoint-

ed at the apparent ease [with which] this fraudulent claim has been received and allowed by the Institution, and, in justice to myself, I request that this communication be placed before the officers of the Institution at their next meeting, with a view to their taking such action in the case as truth, justice, and science demand. Your obedient servant, B. J. D. IRWIN, Surgeon, U.S. Army, General Hospital, Memphis, Tennessee."

REF. No. 17, 1865, HENRY

Following is the reply to Dr. Irwin's protest from Professor Joseph Henry, Secretary, Smithsonian Institution, under date of July 17, 1865:

"Dear Sir: Your letter of June 27th in reference to the meteorite presented by you to this Institution was received during my absence or would have had earlier attention. Nothing was farther from our intentions, in our account of this specimen, than to do you an injustice, and we greatly regret that there should be even the appearance of this kind in regard to one to whom we are under so many obligations as yourself. We should not in all probability have used the name of Ainsa in connection with the meteorite, had it not been given to it and announced to the scientific world by Professor Whitney of the California Geological Survey, by whom the specimen was first examined on its way to the Institution. It is exceedingly difficult to change the first name given to a specimen of natural history, however erroneously it may have been applied. As, however, we are desirous of doing justice to yourself in this matter, we propose to attempt to alter the denomination of the meteorite to that of the IRWIN-AINSA METEORITE, and, as it has not yet been subjected to the critical chemical and physical examination proposed, we will, in the final article, give its new name and explain the reason for so doing. The statements in reference to the meteorite given in our report were derived from Ainsa's letters and a newspaper account in a San Francisco journal, and, at the same time, we had no reason to consider them otherwise than correct. The proposed change in the name has been put on the specimen, as it is now exhibited as one of the most interesting objects in the Smithsonian Museum. I am Very respectfully your obedient servant, JOSEPH HENRY."

REF. No. 18, 1866, HENRY

From *Rept. Smithsonian Instn. for the Year 1865* (Joseph Henry, Secretary), p. 67 (January, 1866):

"In the report of 1863, mention is made of the presentation of a large and remarkable meteorite to this Institution, to which the name had been assigned, in California, of the *Ainsa Meteorite*. Acknowledgments were duly made to Dr. B. J. D. Irwin, Surgeon, U.S. Army, for his services in behalf of the Institution in procuring this interesting specimen, but, from additional facts which have come to our knowledge, we are induced to add the name of this gentleman to the specimen and to label it the *Irwin-Ainsa Meteorite*."

REF. No. 19, 1871, PUMPELLY

Following is an excerpt from "Across America and Asia," 5th Ed., New York, by Ralph Pumpelly, Professor in Harvard University and Mining Engineer:

"In the autumn of 1860, I reached the end of the railroad in Missouri. My immediate destination was the silver mines of the Santa Rita, in Arizona, of

which I was to take charge, as mining engineer. Having secured the right to a back seat in the overland coach as far as Tucson, I looked forward, with little dread, to 16 days and nights of continuous travel. The most interesting objects of curiosity in Tucson were the two great masses of meteoric iron, which have been mentioned by various travelers who have passed through this region. These had long lain in a blacksmith's shop,* serving as anvils, and nothing but the impossibility of cutting them had saved them from being made into spurs, knives, *etc.* The larger mass, half buried in the ground, had the appearance of resting on two legs, but, when removed in 1860, it was found to be a ring of iron weighing about 1600 pounds. It now lies in the Smithsonian Institution, bearing the name of the *Ainsa Meteorite,* having been brought in 1735 from the Sierra de la Madera by Don Juan Bautista Ainsa and forwarded to Washington by his descendants; the other, shaped like a slab, about 4 feet long and 18 inches broad, weighs 632 pounds and is now in San Francisco, having been sent thither in 1862 by General Carleton."

ADDENDUM REF. NO. 20, 1862, FROM THE SAN FRANCISCO *Weekly Alta*

The following additional reference from the *Weekly Alta,* San Francisco, California, of November 15, 1862, relates to the Carleton meteorite, which was presented to the City of San Francisco by General James H. Carleton of the California Volunteers:

"Monster Meteoric Stone: A meteoric stone of mammoth proportions fell in Tucson, Arizona Territory, some years since. It measures 4 feet 2 inches in length, 18 inches in average width, and in thickness 1 to 10 inches, resembling much in shape a whale's shoulder-bone. When rubbed, it somewhat resembles polished steel, and its resonance when suspended is remarkable. This visitor from the upper air is of great weight and, as a curiosity, will be highly prized. It is now at the Quarters of the Federal Government in this city, having been presented by the Commanding Officer at Tucson to the Department here."

[*Concluded*]

The Cavour, South Dakota, Siderites: A Newly Reported Fall

Under the title of "Cavour Meteorites," writes Mrs. W. J. Lindsey of Cavour, South Dakota, in *The Mineralogist* (Portland, Oregon), **11**, 316, October, 1943:

"Several years ago Henry De Vries, who resides about 11 miles southwest of Cavour, South Dakota, found an odd-appearing rock on his farm and carried it home. In the spring of 1941 Mr. and Mrs. De Vries read an article in *The Mineralogist* magazine describing meteorites. Their specimen appeared to fit the description of a meteorite.

"Later Mrs. De Vries brought the specimen to the writer for examination. Various tests were made and the writer also thought the specimen was an iron meteorite. To make certain we took the specimen to Dr. Over at the museum of the University of South Dakota. After various tests Dr. Over stated the specimen was a typical nickel-iron meteorite.

"Late in 1941 William Anderson, on a farm adjoining the De Vries property,

"*The description of both pieces has been given by Professor J. D. Whitney in *Proc. Calif. Acad. Sci.*, **3**, pp. 30 and 48 [1863], from which papers the above details have been extracted."

also found an iron meteorite, and still another in the spring of 1942. Anderson later sold one of his specimens to F. J. Richards of Esmond, South Dakota, and the other to the writer. The De Vries meteorite rests in the museum of the University of South Dakota, at Vermillion. The 2 specimens found by Anderson are shown in the accompanying photograph [not reproduced here].

"Curiously enough, these 3 meteorites are almost of the same weight. They weigh 8 pounds; 8 pounds, 6 ounces; and 9 pounds. The crust of all specimens is of the typical dark brown, and they show the characteristic pits and 'thumb prints.' So far as can be learned no one saw the specimens fall.

"No search has been made for additional specimens. The 3 referred to here were found by accident. We have shown our meteorite to the youngsters of the vicinity in the hope that additional specimens may be found. It would seem likely that these specimens may be part of a meteorite 'shower,' and additional examples will be forthcoming. The writer will be glad to show the meteorite to any visitors who may call. The name *Cavour* [*South Dakota*] *meteorites* is suggested for this find."

The coördinate number of the newly reported fall, based on the longitude and latitude of Cavour, is 0980,443.

Reviews of Johnson's "The Origin of the Carolina Bays"

The following notices and reviews of Douglas Johnson's important work, "The Origin of the Carolina Bays" (*Columbia Geomorphic Studies, No. 4*), xiii + 341 pp. *&c.*, Columbia Univ. Press, New York, 1942, have appeared up to date:

(1) By Lewis G. Westgate, in *Sky and Telescope*, **2**, No. 4, 16, 1943;
(2) In *P. A.*, **51**, 114-15, 1943 (unsigned);
(3) In *C.S.R.M.*, **3**, 79-80; *P. A.*, **51**, 167-8, 1943 (unsigned);
(4) By J. Hoover Mackin, in *Jour. Geol.*, **51**, 138-40, 1943; and
(5) By Frederick C. Leonard, in *Astroph. Jour.*, **98**, 132-3, 1943.

VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

By LEON CAMPBELL, Recorder

Variable Stars at the A. A. S. Meeting: Among the papers presented at the recent meeting of the American Astronomical Society in Cincinnati, Ohio, was one by Dr. S. Gaposchkin on the light curve of the spectroscopic binary H.D. 176853. The star, according to 890 estimates made from Harvard plates, has an amplitude of variation of only 0.13 magnitude, and in spite of its very small range presents a very satisfactory light curve. The radii of the two components, spectral types B5 and B8, respectively, are essentially equal, about six times that of the sun, and with masses in the ratio of 13 to 7, that of the B5 star being the greater. The author suggests that the binary be studied photoelectrically because of the very small range. The star is somewhat below the sixth magnitude.

Dr. Gaposchkin's second paper dealt with the light curve of Nova Aquilae, 1943; see these notes for November.

Orbital Elements and Apsidal Motion of AR Cassiopeiae: Another paper was by R. M. Petrie of the Dominion Observatory at Victoria which discussed the radial-velocity observations of the eclipsing binary AR Cassiopeiae. Petri finds that the orbit of the star is slowly turning in its own plane, describing a complete cycle in about 400 years. This period is the largest apsidal period to be determined spectroscopically.

The brighter star of the system is itself an eclipsing binary of spectral type B4, and contributes 97 per cent of the total light of the system. Its diameter is approximately six times that of the sun, and its luminosity about 250 times as great. The fainter star appears to be of spectral type A. The two components revolve about their common center of gravity in a period of six days and their average separation is about one-half the radius of the orbit of the planet Mercury.

Variations in Brightness of Comet Whipple, 1942 g: A very interesting paper describing the light variations of Comet Whipple, 1942 *g*, was presented by Dr. N. T. Bobrovnikoff of the Perkins Observatory. Observations to the number of 213 by ten observers, mainly in this country and Russia, were secured and although made with instruments of differing types and sizes, they were all reduced to the Harvard Photo-Visual system and referred to those as made in a 2½-inch telescope.

There is evidence of a periodic fluctuation in brightness of the comet with a 30-day period. Actual maximum occurred a month later than the theoretical date. The observed light curve fits the theoretical curve very well during January and the early part of February, and again from April 15 to July 3. Something out of the ordinary happened in the middle of February to cause the comet to increase in brightness by 1.6 magnitudes. There is evidently much yet to be learned about the changing brightness of comets, and doubtless the problem is one that requires the application of highly accurate photometric devices.

Current Notes on A. A. V. S. O. Variables: T Cassiopeiae is well on its way to maximum and the customary secondary minimum, due early in 1944, should be carefully observed.

Gamma Cassiopeiae continues to hover around magnitude 3.0.

RX Andromedae passed through four well-observed maxima in the past two months; on September 1, 14, and 29, and on October 28, with possibly one on October 18.

S Cassiopeiae was at maximum early in July and is now well on the decrease to minimum. This star, with one of the longest periods known for long-period variables, is not due again at maximum until March, 1945.

RV Andromedae, with a period of approximately 170 days, and a relatively small range—less than two magnitudes—is holding fairly closely to its assigned period, but with irregularities in form of light curve from cycle to cycle, rather more than should be expected for an M emission spectrum star.

TZ Persei, a star of the Z Camelopardalis type, was observed at maximum on September 11 and 30, and October 20. The average length of the cycle between maxima is 17.5 days. This star, like its prototype, has been known to remain at nearly constant magnitude for a whole year at a time.

Mira, o Ceti, is due to begin its next rise to maximum in December and should attain naked-eye visibility late in January. The rate of increase can be very rapid, and the brightness at maximum may be anywhere between the second and the fourth magnitudes, therefore it requires close attention on the part of

observers, especially those with little or no telescopic aid.

Nova Persei, 1901, continues to oscillate between magnitudes 12 and 13 in an irregular manner, quite typical of decadent novae.

SU Tauri may be considered as having practically attained its normal maximum brightness, slightly above the tenth magnitude, nearly 600 days having elapsed while the star was below the tenth magnitude.

Alpha Orionis, varying irregularly between zero and first magnitude, is becoming well placed for observation during the winter months and care should be exercised in choosing comparison stars which are approximately at the same altitude as the variable when estimates are made.

SS Aurigae was finally caught at a maximum of the long type in September. The increase in light was evidently very rapid, from fainter than magnitude 13.2 on September 21, to magnitude 10.5 on September 22.

SW Geminorum appears to satisfy the assigned period of approximately 680 days, although the range in variation is relatively small.

R Geminorum is due for a rapid rise to maximum during the next three weeks. With a period only a few days longer than a year, the minima have been difficult to observe in recent years because of the proximity of the region to the sun at those times.

Z Camelopardalis was at maximum late in August and again late in September, about a month apart. In fact the intervals between the last five maxima have averaged some five days more than has usually been the case.

R Leonis should be at maximum early in January, slightly above the sixth magnitude.

S Chamaeleontis, sometimes referred to in the variable star catalogues as non-variable, appears to hold around a mean magnitude of 6.6, with only a small deviation from that value; deviations entirely within the accidental error of visual methods. The same conclusion is reached by the Milton Bureau from a study of the photographic observations. More highly accurate methods of observation should be employed to confirm the reality of the seemingly small variation.

S Apodis, according to observations made up to September first, appears to be slowly increasing in light, magnitude 12.0 on that date.

R Scuti has not passed through a deep minimum—fainter than the sixth magnitude—since September of last year. The star should be carefully watched during the next few months to see that a deep minimum does not escape attention.

RY Sagittarii continues to gradually increase in brightness. It has attained magnitude 7.0, normal magnitude at maximum being 6.5.

ER Lyrae, usually listed as an irregular variable, has passed through two maxima recently, one in November, 1942, the other in June of this year. If we are correct in assuming the validity of these observations—between magnitudes 11 and fainter than 14—the period would appear to be around 200 days. The star may prove to be one of the shorter period long-period variables.

AV Cygni, one of the so-called RV Tauri type stars, appears to hold rather uniformly to a period of 90 days, but not with the usual alternation of shallow and deep minima found in other stars of this type.

Chi Cygni has apparently reached its still-stand phase on its present rise to maximum at the tenth magnitude slightly earlier than at the previous rise. The star should be well observed during the next two months, especially because after such still-stands the increase in light to full maximum is decidedly rapid.

UU Aquilae, one of longer period SS Cygni-type stars, was observed at maxi-

mum on June 24, 1943.

AB Draconis, one of the shorter period Z Camelopardalis-type stars, with a mean cycle of about 12 days, was observed at maximum about August 30, and on September 12 and 23.

P Cygni, an old nova which appeared in 1600—maximum magnitude three—remains quite consistently at the fifth magnitude. Only an occasional observation of this star is required to keep track of its activity.

V Sagittae, thought by some to be an old nova, has very recently undergone marked fluctuations in light. During October it steadily decreased from magnitude 11 to 13, a behavior not unprecedented, but of interest.

T Cephei should be at maximum, around the sixth magnitude, in December. Its still-stand or secondary minimum should be watched for closely.

SS Cygni rose to maximum very rapidly, from magnitude 12.0 on October 30, to magnitude 8.8 on October 31, and to magnitude 8.4 on November 1. The rise was noted by at least six observers; the maximum proved to be of the short type, and followed the previous rise to maximum by 78 days.

Revised Period of TZ Coronae Austrinae: The Milton Bureau calls attention to a new value for the period of the eclipsing variable TZ Coronae Austrinae. Discovered by Miss Cannon in 1910, the star was found to rise from minimum to maximum in the short interval of two hours and six minutes, but no period was then derived, although the eclipsing nature of the star was recognized.

No further studies of the star have appeared, but in the 1942 edition of Schneller catalogue, the period is given as $2^d.060203$. Upon the reduction of six hundred and fourteen photographic observations it is found that the period given in Schneller's catalogue is almost three times the true period, which is $0^d.68674750$. The light curve is of the β Lyrae-type. The spectrum was classified by Miss Cannon as of Class A0.

Observers and Observations: Four names of new observers appear in the list of contributors of observations received during October: Mrs. A. M. Arrowsmith, of St. Albans, N. Y., H. J. Hopkins, of Portland, Me., Mr. Edward Morrow, of Somerville, Mass., and Russell Wolfram, of Mt. Hamilton, Calif.

Observer	No. Var.	No. Ests.	Observer	No. Var.	No. Ests.
Arrowsmith	1	1	Luft	6	30
Blunck	34	40	Manlin	100	100
Boone	22	22	Meek	71	273
Bouton	13	18	Morrow	5	11
Buckstaff	12	23	Nadeau	93	150
Cousins	50	291	Oravec	6	14
Fernald	220	608	Parks	25	43
Ford	45	49	Peltier	192	278
Garneau	28	30	Reeves	3	7
Halbach	37	37	Rosebrugh	10	51
Harris	48	48	Schoenke	41	114
Hartmann	150	174	Sill	70	70
Hiett	14	20	Stone	4	4
Holt	87	104	Topham	63	63
Hopkins	8	8	Vohman	19	26
Howarth	14	14	Webb	16	19
Jones	47	121	Weber	88	88
Kearons	79	182	Wolfram	6	6
Kelly	12	17	—		—
deKock	70	252	38	Totals	3316

November 15, 1943.

Comet Notes

By G. VAN BIESBROECK

In the course of last month two of the periodic comets expected at this time have been recovered.

The first one, PERIODIC COMET COMAS SOLÁ 1927 III, was found by Miss Oterma at Turku (Finland), according to a telegraphic report of October 2 which stated that the object was located near the position predicted by C. Dinwoodie and W. P. Henderson in the *Handbook of the British Astronomical Association* for 1943. I recorded the comet on October 25 as having a sharp nucleus of magnitude 14, surrounded by a coma some 25″ in diameter with a faint tail 3′ long in position angle 270°. The total brightness corresponded to magnitude 13 so that visibility is limited to large telescopes. The measurements on that same date indicated that the comet will come to perhelion only four hours earlier than was foreseen by the English computers, a remarkably close prediction. The following ephemeris shows the motion of the comet which now crosses the favorably situated constellation of Pisces.

		α	δ
		h m	° ′
1943 Dec.	6	1 50.4	+3 27
	14	47.9	4 38
	22	47.7	6 0
	30	1 49.8	+7 31

The brightness is slowly increasing which makes it probable that the comet, which comes to perihelion next April 11, will remain in reach for several months.

After it was discovered 1926 November 4 the comet was followed for seven months which enabled Miss Vinter-Hansen to compute a reliable orbit corresponding to a period of 8½ years. This led to the reobservation in 1935 and we now see the second return since the discovery.

The other recovered object is PERIODIC COMET D'ARREST, which I recognized first on a plate exposed October 24 at the prime focus of the 82-inch reflector of the McDonald Observatory, Fort Davis, Texas. The position then was:

1943 October 24.10021 U.T. $20^h\,0^m\,48^s.87$, $-27°\,58'\,44''.1$ (1943.0).

The comet showed a nearly stellar nucleus of magnitude 16, eccentrically situated in a coma 4′ in diameter, spreading into a broad fan in position angle 260° so as to make a short tail in that direction. In a 6-inch finder the total magnitude was estimated at 12.5.

Earlier trials at the Yerkes Observatory under much less favorable circumstances proved futile. The object was evidently too faint to be seen from there at its far southern declination. Since it had not been observed for twenty years the predicted position might have been appreciably in error and I asked the modern comet-ferret, L. C. Peltier, to explore the region. Not finding anything there he swept the remainder of the sky with the result that he independently discovered comet Diamaca as was mentioned last month.

As it turned out the prediction of the position of the periodic comet by A. W. Recht, Denver, who had made an exhaustive study of its motion, proved to be quite accurate. Although the comet had gone three times around its orbit since it was last seen a correction of only 1.2 days in the time of perihelion suffices to fit the ephemeris to the new observation. Dr. Recht's work had brought

out the fact that this comet, observed at many returns since its first discovery in 1851 at Leipzig, showed unexplained variations in its orbit, even after all known planetary influences were taken into account. The most marked change during the period 1851 to 1923 was a slow but steady increase in the major axis with a corresponding retardation in the date at which the comet came closest to the sun.

This made accurate predictions difficult and partly accounts for the fact that several returns have been missed. It was last seen in 1923, missed in 1929 and 1936, but has now luckily been found again.

With the help of the new measures, Dr. Recht has improved the ephemeris as follows:

1943		α h m	δ ° ′
Dec.	6	22 30.2	−24 10
	10	22 42.3	−23 18
	14	22 54.0	−22 24
	18	23 5.3	−21 28
	22	23 16.4	−20 29
	26	23 27.2	−19 30
	30	23 37.6	−18 29

Already the light-intensity is decreasing since the comet passed perihelion September 22 and its present location is unfavorable for northern observers.

Comet Diamaca-Peltier, which was first mentioned last month, seems to have been followed only a short time. L. C. Peltier is apparently the only observer in this country who sighted the object. He writes that he estimated the brightness as follows on four nights:

1943	Sept.	18	10.5 mag.
		19	11.5 mag.
		21	12.0 mag.
		22	13.0 mag.

the last figure being somewhat uncertain due to the proximity of ϵ Herculis. I was at that time on my way between the Yerkes and McDonald Observatories and the absence of an ephemeris for the fast moving object and its faintness soon made the search hopeless. Not until a month later was an orbit announced. Early European observations, which remained unknown here, must have made the computation possible. The following result by Naur (?) was broadcast October 18 through the center of telegraphic information at Cambridge, Mass.:

Orbit of Comet Diamaca-Peltier

Perihelion time	1943 August 21.538
Node to perihelion	56°2′
Node	82 15
Inclination	161 16
Perihelion distance	0.7581 A.U.

It shows that the comet came inside the earth's path in August and moved in a retrograde direction. The region thus predicted was photographed on October 24 at the McDonald Observatory but I could find no trace of the comet although stars as faint as magnitude 18 were recorded on the plates. The rapid decline indicated by Peltier's estimates probably accounts for the failure.

At the end of October, Periodic Comet Schwassmann-Wachmann I was again recorded as appearing almost like a star of magnitude 17 or 18, except for an extremely faint and small nebulosity around the nucleus. My record was not

long enough to establish variations in appearance of the kind that have been shown repeatedly in this faint object.

At the same time plates were exposed at the McDonald Observatory in a search for the PERIODIC COMETS DANIEL 1909 IV and SCHAUMASSE but without success.

Williams Bay, Wisconsin, November 12, 1943.

Notes from Amateurs

Louisville Astronomical Society Anniversary

The Louisville Astronomical Society has celebrated its tenth anniversary—ten full years of interesting times together, seeking knowledge of the vast universe about us, and finding in that knowledge a peace and release from the turmoil of the world today.

During these years we have had the privilege of having several noted astronomers as guest speakers before our meetings. We have had many enjoyable out-of-door meetings, some for members only with a mixture of sociability and star gazing. Others have been held in the parks where instruments were set up and the public invited to use them. We have counted meteors, watched eclipses, and the zodiacal light, given astronomical picture shows and lectures to groups, and in many ways have pleasantly and profitably filled the years.

Many of our former members and other friends of kindred interests were with us for our anniversary meeting on November 16. The program included the reading of greetings from some of our distant friends, a short history of the Society read by Mr. Oscar W. McCarty, a charter member, who concluded his reading by presenting the secretary with a lovely fountain pen, a gift from the program committee. This was followed by a group of most interesting astronomical movies. Four of these, secured from the McMath-Hulbert Observatory of Pontiac, Michigan, were: "Eclipse of the Sun, August, 1932," "Trip to the Moon," one of "Active Solar Prominences," and one of "Eruptive Solar Prominences." Also a kodachrome film from the Amateur Astronomical Association of New York City which was thoroughly enjoyed. This was made during the lunar eclipse of August 25, 1942, and showed, not only the progress of the eclipse, but pictures of the group at work with their instruments during the filming of the pictures. Dr. Walter Lee Moore, president of the Society operated the projector while Mr. Charles Strull made comments during the showing.

At the close of the program, the guests were welcomed at an informal reception.

MARY EBERHARD, *Secretary.*

General Notes

Mr. David E. Hadden of Alta, Iowa, a careful observer and recorder of weather data since 1890, died on September 20. Mr. Hadden was also interested in astronomical observations and made numerous reports of his work to this magazine. His work was chiefly with sunspots and variable stars.

Junior Astronomers Needed

In order to meet the immediate and anticipated need for Junior Astronomers in the Naval Observatory, Navy Department, Washington, D. C., the Civil Service Commission is seeking persons qualified in this field who are available for Government employment.

Junior Astronomers may assist in making astronomical observations and computations and prepare publications from information obtained; perform research or investigate work; and may make calculations based upon field data and apply such calculations to specific cases.

These positions will be filled through the civil-service examination now open for Junior Astronomers. The positions pay $2,000 a year (plus $433 over time pay). There is no written test and no maximum age limit for this examination. Applicants will be rated on their education and experience. They must have completed a 4-year college course including or supplemented by 12 semester hours in mathematics and 12 semester hours in astronomy. No experience is required but credit will be given for appropriate experience.

Persons who have received their bachelor's degree, but who have completed less than the number of science courses in mathematics or astronomy required for the Junior Astronomer examination but who have had some training in astronomy, mathematics or physics, are urged to file their applications for the Junior Professional Assistant examination. If they receive an eligible rating, they will be considered for appropriate vacancies.

Persons now using their highest skills in war work should not apply. Appointments in Federal positions will be made in accordance with War Manpower Commission policies and directives and employment stabilization plans.

Those interested in this matter should communicate with the United States Civil Service Commission, Washington, D. C.

Book Reviews

Science from Shipboard, by thirteen authors, with foreword by Harlow Shapley. (Science Service, Washington, D. C., 1943. 268 pages. 25c.)

If this little volume had appeared in normal times, we should describe it as a handbook designed to enhance the pleasure of a voyage by acquainting the traveler with the things to be seen above, below, and all about him. Actually, the purpose of the book is to provide useful information to the men and women of our Armed Services, and to create a better appreciation of science and its methods, inasmuch as this is a war to be won largely by logic.

The first section of about fifty pages deals with meteorology, with particular attention to weather forecasting at sea. This is followed by a chapter on the sun, moon, and planets. The cause of the seasons is explained, and a table is given by which the brighter planets can be located until 1947.

Many of the readers of this book will be making their first voyage, and for the first time, perhaps, will have occasion to think about the problems of time. For these is included a chapter on the various kinds of time, the date line, the calendar, and the sundial. A series of twenty-four star charts with complete explanation will enable the traveler to explore the sky no matter where he may be. The astronomical portion of the book is concluded with a description of our

Milky Way system with its star clusters, variable stars, novae, and bright and dark nebulae.

A non-mathematical treatment of navigation is included, with sufficient diagrams and tables to be of value in case of emergency. Geology finds a place in the description of ocean islands and ever-changing shore lines. Sea life is always of great interest to the voyager who will be much fascinated with the chapters on whales, flying fish, luminescent creatures, and oceanic birds. The ship itself is discused in a chapter dealing with hull construction, buoyancy, stability, propulsion, and resistance. The final topic is the traveler himself. The cause of seasickness, vision, vitamins, infections, exposure, and thirst are matters of great importance. These are presented as by a wise physician, with very practical suggestions for the well-being of the voyager.

Carleton College. WILLIAM A. CALDER.

Philips' Chart of the Stars, edited by E. O. Tancock. (George Philip and Son, Ltd., 32 Fleet street, London, E.C. 4. 3/6 net.)

The details of this chart were given in a review in Volume 50, page 463, of this publication. It was stated there that its arrangement and contents entitled it, in our judgment, to be recommended very highly as a guide in a study of the starry skies with the naked eye. A copy of the revised edition of this chart, now available, embodies all the commendable features of the former one, and we are pleased to call the attention of our readers to it again. C.H.G.

Publications Received.—The publishers of POPULAR ASTRONOMY hereby acknowledge receipt of the following named publications and express their great appreciation of the courtesy shown on the part of those who have sent them.

Contributions from the Mount Wilson Observatory:

No. 668. "A Survey of the Spectra and Radial Velocities of the Less Regular M-Type Variable Stars," by Alfred H. Joy.

No. 669. "Mean Absolute Magnitudes and Space Motions of the Irregular Variable Stars," by Ralph E. Wilson.

No. 670. "Investigations on Proper Motion. XXII. The Proper Motion of the Open Cluster Messier 67," by Adriaan van Maanen.

No. 671. "Nuclear Emission in Spiral Nebulae," by Carl K. Seyfert.

No. 672. "Measurements in the spectrum of τ Scorpii," by Paul W. Merrill and Walter S. Adams.

No. 673. "The Structure of Interstellar H and K Lines in Fifty Stars," by Walter S. Adams.

No. 674. "The Direction of Rotation in Spiral Nebulae," by Edwin Hubble.

No. 675. "Nova Ophiuchi of 1604 as a Supernova," by W. Baade.

No. 676. "The Spectrum of the Nebulosity Near Kepler's Nova of 1604," by R. Minkowski.

No. 677. "The Spectrum of Nova Cygni 1942," by Roscoe F. Sanford.

Circumstances beyond our control have conspired to delay this issue. We expected some delay because the personnel at the printing office has been reduced to a minimum by war demands. We did not expect the depleted force to be further limited as a result of the mild epidemic now effective. This, however, has happened. We beg the indulgence of our subscribers in this emergency. EDITOR.